# Space/Aeronautics

THE MAGAZINE OF AEROSPACE TECHNOLOGIES

NOVEMBER 1961

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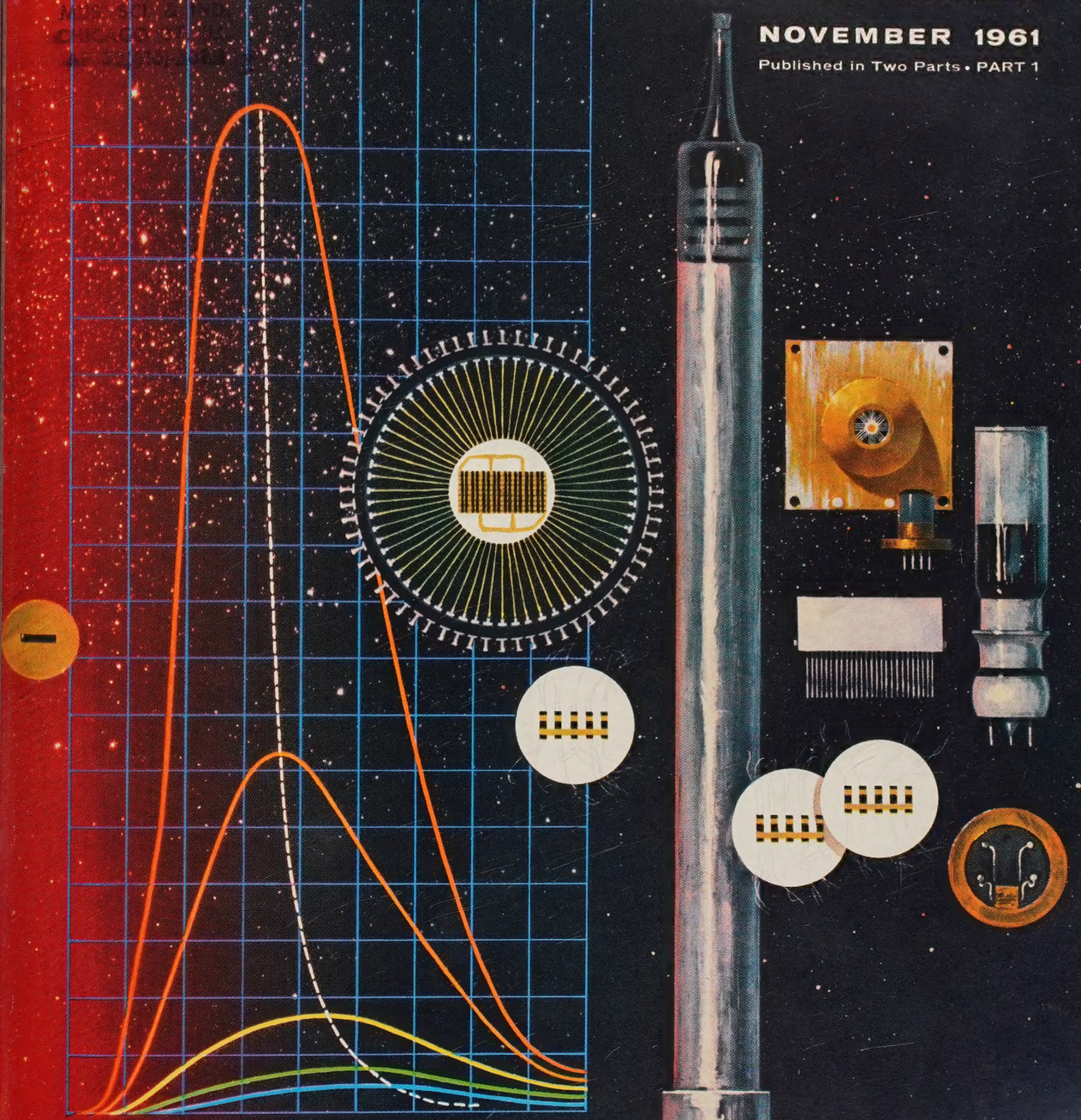

## Infrared Detectors

Hydrostatic Booster Testing • PNPN Devices

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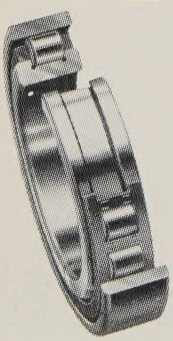

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# Space/Aeronautics

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## REPRINTS

In response to numerous inquiries, Space/Aeronautics is makir available reprints of "Communications Satellites: The Technic Problems," a special S/A survey printed in the September issu free of charge. If you missed reading this important and compr hensive article, or would like extra copies send your name, titl company, and address to:
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**COMING**

Like this month's issue, next month's will come to you in two parts. Its second part (again an entirely separate package) will be devoted to "Design Guidelines for Space and Airborne Electronics," a compendium of information selected for its usefulness to the engineer actually working on aircraft, missile, or spacecraft electronics. It will include two staff-written survey articles on general design practices and on environmental factors and a series of articles by electronic experts, with the emphasis on thermal, mechanical and electric design. (We're tempted to tout this special issue as a must for the electronic designer's bookshelf, but actually we suspect he'll be having it lying open on his desk half the time.) ■ We all know what the Reds' cosmonaut flights meant in terms of propaganda. But what did they mean technically? Watch for a revealing engineering analysis next month.

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# abstracts

Systems Engineering, Electronics

## What have we got to counter the ECBM threat?

Discusses principles of anti-ICBM defense, and reviews defense systems that the U.S. is working on. These include Zeus, which is nearly ready for use, Arpat, Helmet, Bambi, and Saint.

by James Holahan, Electronics Editor

space/aeronautics 36/5 (Nov. '61) p. 50

Testing, Structures, Propulsion

## Keeping hydrostatic tests from adding booster weight

Analyzes the weight penalty that may result from liquid booster tank walls being made thicker to withstand hydrostatic testing pressures. Shows parameters that determine this penalty, its order of magnitude, its effect in terms of payload weight, and the relationship between extra weight and tank diameter.

by Carl R. Liebermann, Martin

space/aeronautics 36/5 (Nov. '61) p. 56

Materials, Production Engineering, Accessory Components

## Super-alloys for high-temperature springs

Reviews representative super-alloys that look good for spring operation at 400-1400 deg F in aerospace assemblies. Test data are given, and the effects of processing variables on performance are discussed.

by V. A. Stanton, National-Standard

space/aeronautics 36/5 (Nov. '61) p. 73

Accessory Systems, Testing

## X-15's cryogenic cooling system is simple and lightweight

Reports on the X-15's cryogenic air conditioning and pressurization, which use liquid nitrogen metered through fixed flow control orifices. Describes the comprehensive testing that was required for sizing of the orifices, and the special problems that had to be overcome.

by C. P. Bowman, North American Aviation

space/aeronautics 36/5 (Nov. '61) p. 61

Electronics

## Infrared detectors

An extensive state-of-the-art report, consisting of a review of recent new designs and applications, analyses of quantum point, imaging-tube, and thermal detectors, and a tabulation of IR detectors available for aerospace applications.

space/aeronautics 36/5 (Nov. '61) p. 104

Testing

## Semiconductor strain gages: small size, high output

Describes advantages of semiconductor strain gages and progress in their design. Reports on a variety of new applications for semiconductor strain elements, ranging from static and dynamic strain gages to high-temperature sensors and pressure transducers.

by Irwin Stambler, Associate Editor

space/aeronautics 36/5 (Nov. '61) p. 64

Electronics

## PNPN devices

Survey of PNPN semiconductor devices, all of which offer the advantages of reducing the size and complexity of circuitry. High-power PNPN silicon-controlled rectifiers, lower-power solid-state switches, and new PNPN devices that can be triggered off as well as on are discussed.

by James R. McDermott

space/aeronautics 36/5 (Nov. '61) p. 125

Structures, Testing

## Drop tests prove out inflatable lunar decelerators

Describes a pneumatic decelerator system for soft landings on the moon and planets. Reports on drop tests of a model scaled to simulate the actual forces of a landing on the moon.

by A. E. Gallagher & A. C. Ingelse, Goodyear Aircraft

space/aeronautics 36/5 (Nov. '61) p. 69

Support

## Ground support technology

A separate section surveying the latest design techniques and the industry's capabilities in the aerospace support field. Includes reviews of booster support, in-flight spacecraft support, automatic checkout, and range operation as well as an index to company capabilities.

space/aeronautics 36/5 (Nov. '61) Part 2

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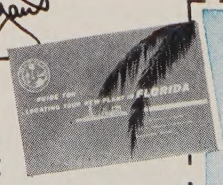

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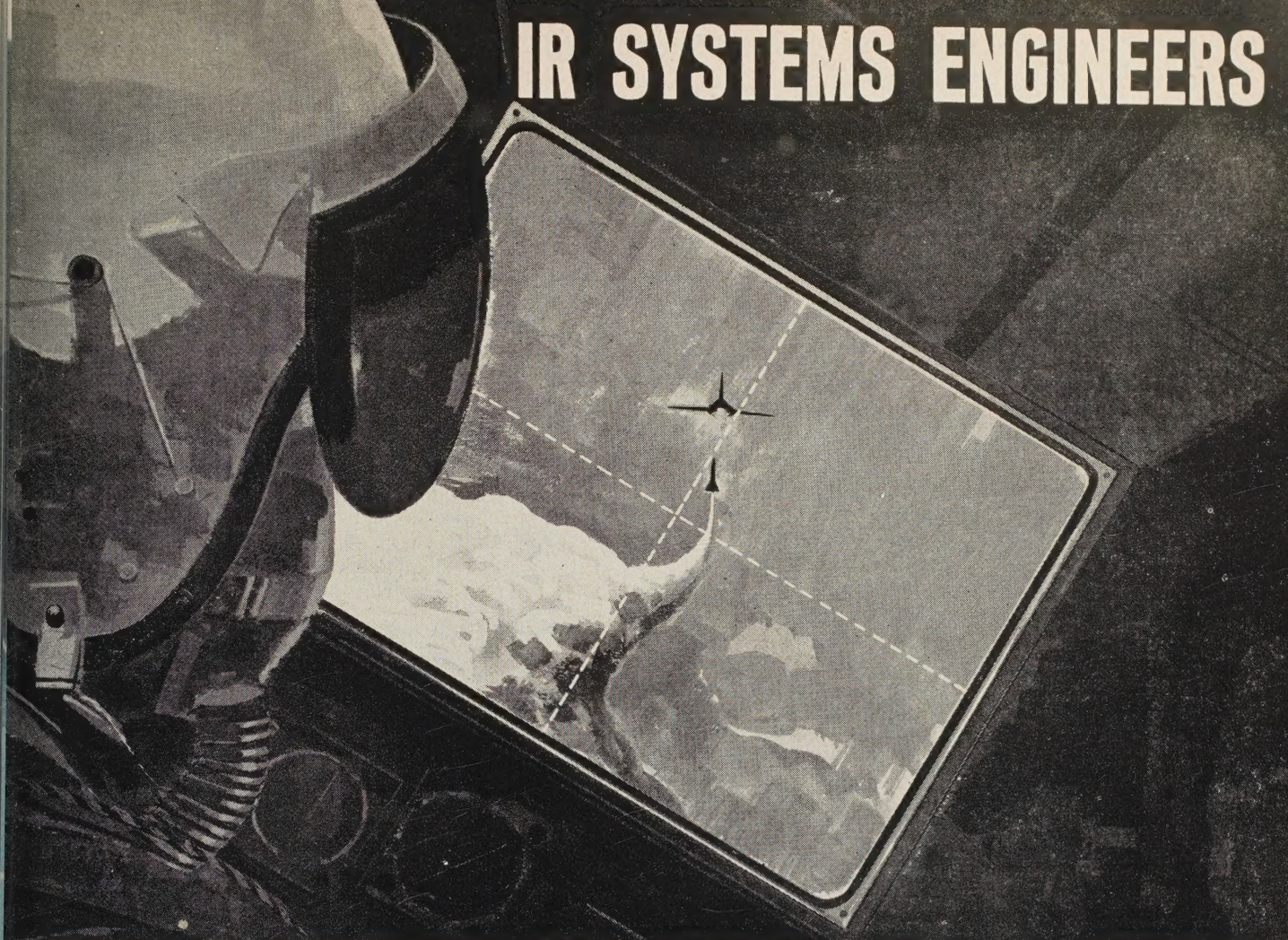

# IR SYSTEMS ENGINEERS

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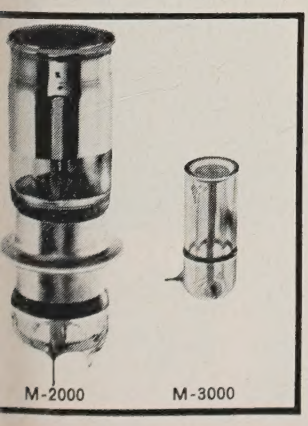
ake advantage of Texas Instruments volume produc-on experience and achieve the high performance andards your IR systems demand with TI high-nsitivity indium antimonide infrared detectors! The gh reliability of these photovoltaic detectors has been oved by many months of actual service in our nation's ost advanced weapon systems . . . you can be confident electrical, mechanical and performance uniformity. eal for use with transistorized circuits, both the -2000 and M-3000 series are designed to operate at liquid nitrogen temperature, and within the two to five micron range. Both detectors feature low noise/high responsivity and utilize painted lead and *kovar* pin construction to assure high electrical circuit reliability. Compactly packaged, the M-3000 series weighs only five grams and is especially designed to withstand strong vibrational stresses. The laboratory-sized M-2000 weighs 38 grams. Specify these cooled indium antimonide IR detectors today for your volume production, high reliability infrared systems.

**Test data on large quantity production lots is available on request.*




**electrical characteristics at minus 196°C**

| Parameter | Detectivity and Impedance Ranges Available | | | | |
|---|---|---|---|---|---|
| Detectivity (D★) | $\geq 4 \times 10^9$ | $\geq 6 \times 10^9$ | $\geq 9 \times 10^9$ | $\geq 12 \times 10^9$ | $\geq 15 \times 10^9$ |
| Small Signal AC Impedance (ohms) | ≥500 | ≥1K | ≥2K | ≥3K | ≥4K |

Time Constant ..... less than 1 microsecond  Spectral Response ..... 2 to 5 microns

D★ .... dependent on area (minimum 4 x 10⁹ at optimum bias)

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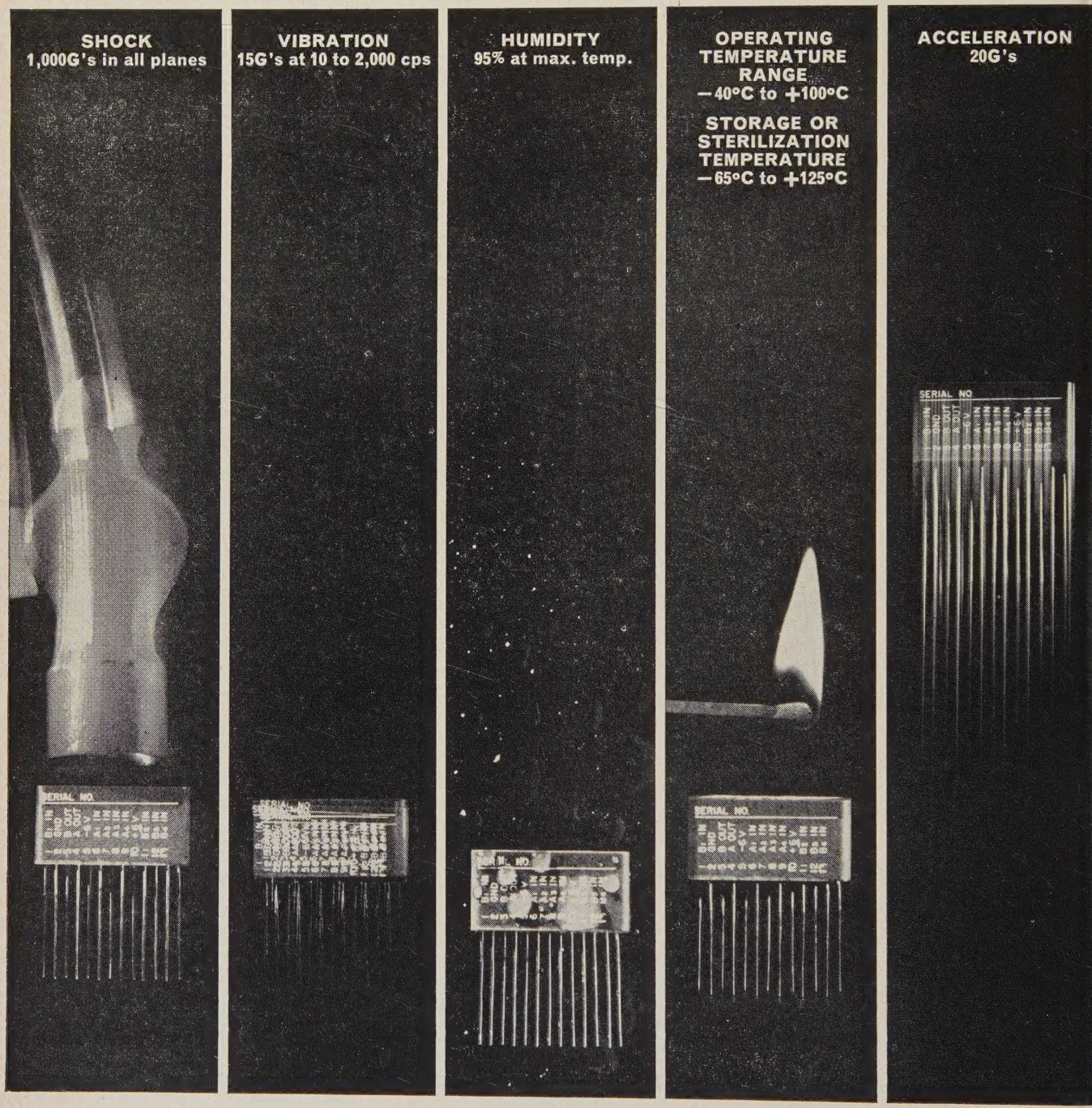


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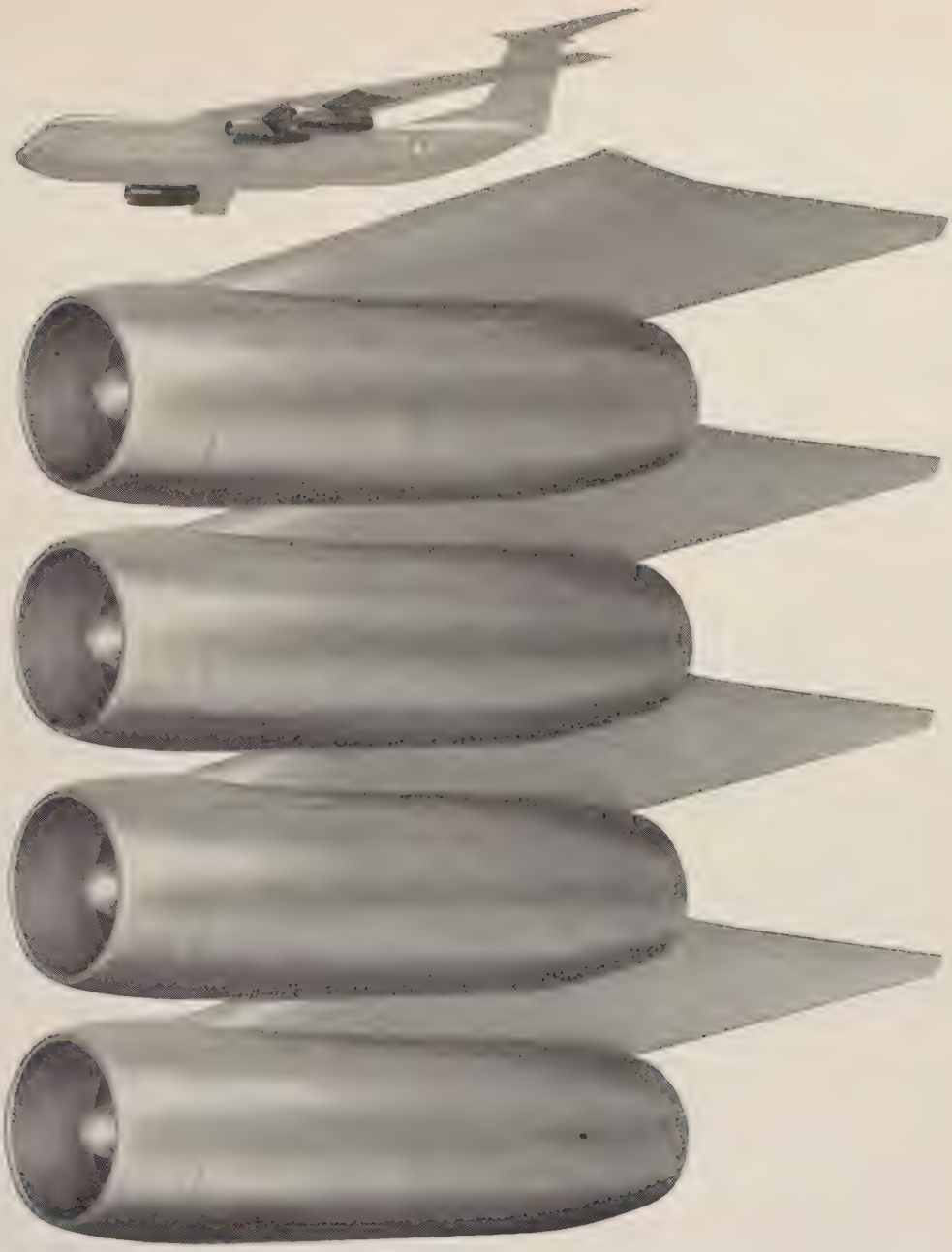

# FOUR POWERFUL REASONS FOR ROHR'S APPOINTMENT TO THE NEW LOCKHEED C-141 JET CARGO PROGRAM

Rohr will build ready-to-install jet pods and struts, like those shown here, for the C-141. More than 18,000 similar assemblies have gone before at Rohr. This vast experience in the field of metal forming is one more reason why Rohr is **America's leading subcontractor to the aerospace industry** — and the first subcontractor named to the huge C-141 program. For more about Rohr, write Mr. A. R. Campbell, Sales Mgr., Dept. 72, Rohr Aircraft Corp., Chula Vista, Calif.

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Chemical Division 3M COMPANY

# KEL-F® BRAND PLASTIC keeps oxygen on tap in new Convair jet—valves pass "10,000 open-close" test!

Valve seats of KEL-F Plastic are used to control standby oxygen for General Dynamics/Convair's new 990 jet-liner, due for regular airline service.

Safe, dependable operation of the standby oxygen system in General Dynamics/Convair's new 990 jet relies on valve seats of KEL-F Brand Plastic. The standby system must be turned on for each flight to ensure crew and passenger safety should high-altitude decompression occur.

For this critical application, Convair selected oxygen valves made by Robbins Aviation, Inc., Los Angeles, Calif., after tests proved these valves capable of long-term leakproof service with minimum downstream pressure surges.

Robbins uses KEL-F Plastic seats both in oxygen and general-purpose valves. Over-torquing cannot score or damage these seats because they combine high compressive strength, low "cold flow," minimum deformation under load. Robbins reports these seats have proved inert to practically all types of fluids and gases—provide a wider temperature range than other materials. They may be used from −320 to +300° F. for continuous duty, up to +350° F. for intermittent heat. Pressures may be as high as 6000 psi. And valves equipped with KEL-F Plastic seats have been tested to 10,000 openings and closings without deterioration!

Another KEL-F product, KEL-F Brand #90 Grease is applied to threads and O-rings in Robbins-made valves. It is unaffected by extended exposure to oxygen, other corrosives —provides excellent metal-to-metal lubrication, exceptional thermal stability.

Now, new KEL-F 81 Plastic incorporates all the well-known properties of the previous plastic, along with better-than-ever uniformity and consistency. See profile at right for property summary.

## Properties Profile on KEL-F® 81 PLASTIC BRAND

KEL-F 81 Plastic is a fluorocarbon plastic, a thermoplastic resin formed by the homo-polymerization of chlorotrifluoroethylene. The high degree of fluorination of KEL-F 81 Plastic is responsible for its chemical inertness and thermal stability. The inclusion of chlorine in an otherwise carbon-fluorine molecule results in exceptional moldability and mechanical toughness.

**Crystallinity.** KEL-F 81 Plastic is crystallizable, but not necessarily crystalline, the degree and kind of crystallinity in a given sample being a function of its thermal history. The "quick-quenched" resin is spoken of as amorphous, and the "slow-cooled" resin as crystalline. When crystalline, KEL-F 81 Plastic is a denser, more translucent material with higher tensile modulus, lower elongation, and greater resistance to the penetration of liquids and vapors. The amorphous plastic is less dense, more elastic, with greater optical clarity and toughness.

**Physical Properties.** The physical properties of KEL-F 81 Plastic combine mechanical, chemical, electrical, and optical advantages. And the most useful applications center around combinations of the following properties:

1. Useful temperature range: from —400° F. to +400° F.
2. Resistance to deformation and flow at high temperatures, pressures
3. Zero moisture absorption
4. Abrasion resistance
5. Radiation resistance
6. Chemical resistance
7. Electrical properties
8. Infra-red transmission
9. Inert to liquid oxygen
10. Flexible in contact with cryogenic fuels

**Processing.** KEL-F 81 Plastic can be processed in the same manner as other thermoplastic resins. Parts of KEL-F 81 Plastic may be specified in any form.

Detailed data on physical properties is contained in a new free brochure. Write for your copy, stating area of interest, to Chemical Division, Dept. KAO-111, 3M Company, St. Paul 6, Minn.

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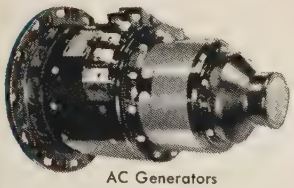
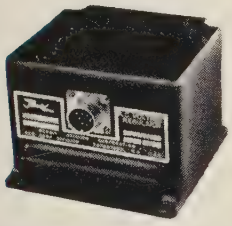


AC Generators



Solid-State AC Voltage Regulators and System Components

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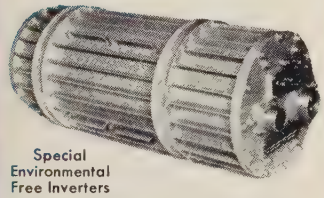

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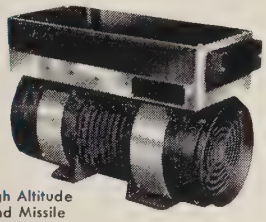

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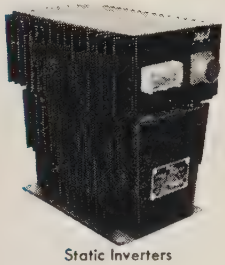
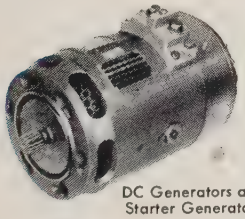
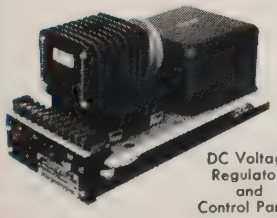


Static Inverters

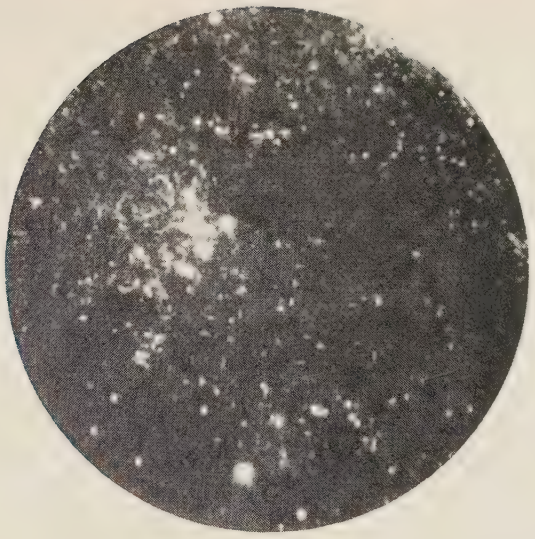
**HIGH-TEMPERATURE DC GENERATING SYSTEMS**



DC Generators and Starter Generators



DC Voltage Regulators and Control Panels



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Bendix® electrical systems are specified for the most demanding applications for many reasons. Bendix combines skillful design and expert engineering with unmatched quality. The result is products which are universally accepted as the *best.*

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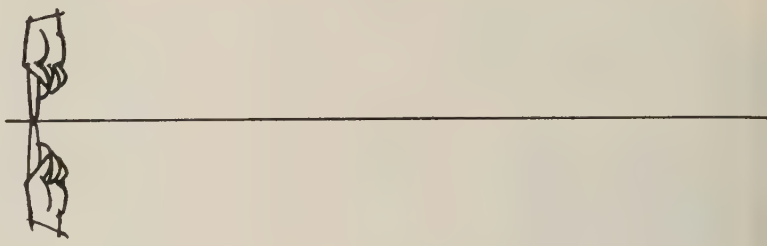
no thicker than (0.003″) 

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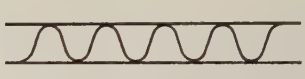
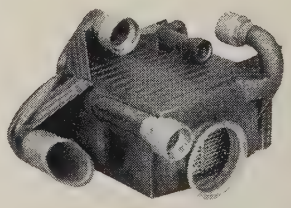
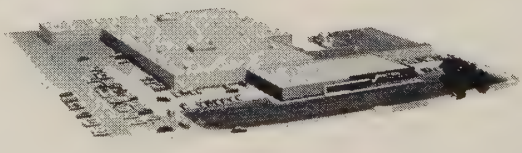
and made into sandwiches  provid

exciting possibilities for heat exchangers 

to which the Janitrol  organization i

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# EXPLORING THE HIDDEN SURFACE OF THE WATER PLANET

*EG&G Underwater Camera, Light and Sonar System*

*Fig 1 17th Century Diving Bell.*

More than one hundred million square miles of Earth's surface are completely unknown to man. These are the super-continents that lie more than a thousand feet under the ocean, where sunlight has never penetrated.

A total of about one square mile of this unknown world has been photographed in various oceans by EG&G automatic underwater cameras. Positioned by EG&G sonar equipment and using EG&G flash equipment for illumination, these cameras have made excellent photographs at 27,500 feet below sea level where the pressure is more than seven tons per square inch.

EG&G is also deeply involved in control instrumentation for the first nuclear rocket engines (Project Rover), the international program for detection of nuclear explosions (Project Vela) and instrumentation systems for non-military applications of nuclear explosions (Project Plowshare). An informative brochure which describes the breadth and depth of EG&G's capabilities is available on request.

For information about employment prospects with this unique, vigorous organization write in confidence to Lars-Erik Wiberg. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

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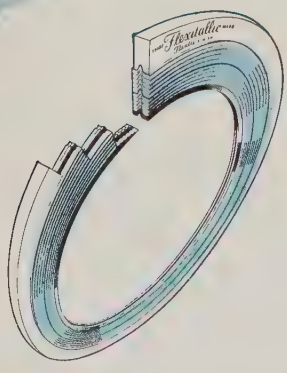
## ...where gaskets must not fail



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SPIRAL-WOUND GASKETS

In designing today's jet aircraft, engineers rely on Flexitallic Gaskets to assure the safe transfer of highly volatile fuels from tanks to engines.

Because of its engineered construction, each Flexitallic Gasket has built-in yield characteristics that provide maximum safety when emergency conditions are encountered.

Every Flexitallic Gasket is designed for the specific job it must do. At Flexitallic, gasket engineers select the special type of metal and filler to be used after considering flange geometry, temperature and pressure ranges, bolt load, corrosion, vibration, and any unusual joint stresses to which the gasket will be subjected.

For temperatures from extreme sub-zero to maximum temperatures compatible with available metals. Pressures ranging to 15,000 lbs. p.s.i., and temperatures to 2500°F. do not impose impossible limitations.

Give us the facts about your most serious sealing requirements — in chemical processing, petroleum, power, marine, aircraft and missiles, diesel, or any other field. There's a Flexitallic Gasket to meet your needs — or Flexitallic will design one.

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# THIS IS Hitco-C . . . A NEW CARBON MATERIAL

Two years of research and development by H. I. Thompson Fiber Glass Co. have produced this latest breakthrough in a high-performance insulation material. Hitco-C's advantages are impressive:

- *Lower thermal conductivity and a low ablation rate compared to other carbonaceous materials.*
- *Compatibility with most resin systems and with all reinforced-plastic fabrication techniques.*
- *Availability in production quantities.*
- *Uniform quality.*
- *Availability in fiber form, and in fabric rolls 33" wide and 50 yards or more in length.*

The characteristics of greater length and a stronger material make Hitco-C fabric superior for coating operations. Molded and laminated parts fabricated with Hitco-C demonstrate excellent physical properties.

*For full information send for Technical Bulletin 1-3B*

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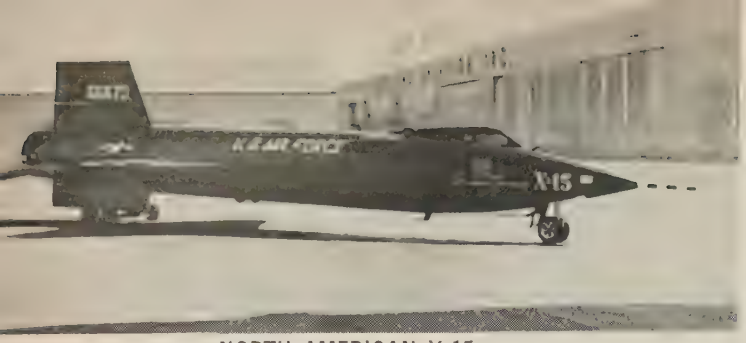


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CONTROL

**Why does the aerospace industry use more Cutler-Hammer switches and power relays than any other brand?**

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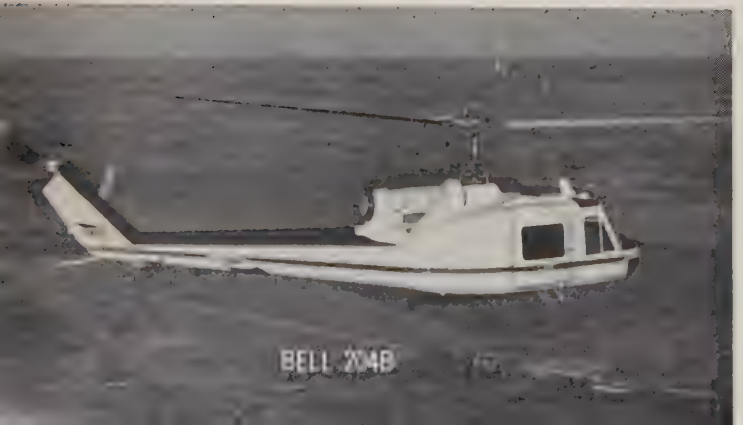


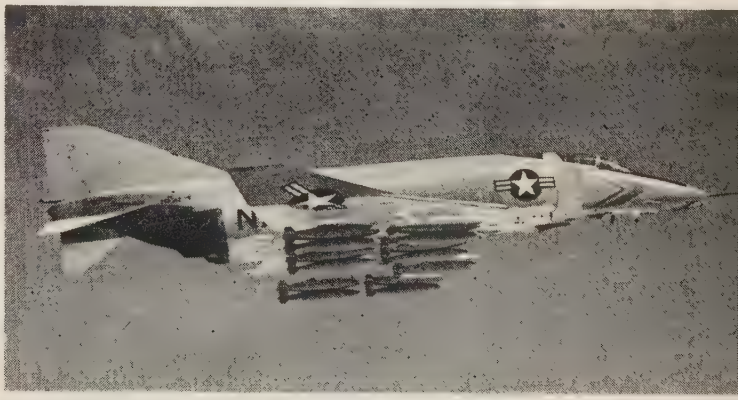
BELL 204B

BOEING 720

LOCKHEED F-104

BEECHCRAFT B95A TRAVEL AIR

NORTHROP T-38



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*Reliability . . . breadth of line . . . experience have made*

# Cutler-Hammer first choice for switches and power relays

You'll find Cutler-Hammer switches and relays in all types of aircraft from private planes to missiles.

All the manufacturers represented in these photos—and many more—have made Cutler-Hammer a preferred source. Since 1920, when we designed and manufactured the first line of switches ever created specifically for aircraft use, Cutler-Hammer has been the standard of quality for the industry.

Our engineers are always ready to help you select the best possible switches, Class O and hermetically sealed power relays and circuit breakers from our extensive line. Or, they'll work with you in design and manufacture to help you solve your particular problem. Better yet, get in touch with your Cutler-Hammer sales office *before* a special problem comes up. For more information, write for Pub. EE 140-W287—88 pages of detailed information.

*WHAT'S NEW? ASK...*

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CONTROL

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Above: Actual Photograph of Grand Central Rocket Co's. ten-foot diameter BIG BOOSTER.
Below: Ten inch diameter RETRO-ROCKET.
Both are in current manufacture at EXCELCO.

# DIVERSiTY

EXCELCO has the Diversity of equipment, experience and skills to produce rocket engines that range from a mere ten inches to a giant ten feet in diameter.

The BIG BOOSTER Rocket Engine illustrated is the western world's largest solid fuel rocket engine. It was built by EXCELCO for the Grand Central Rocket Co., prime contractor on the Air Force program, directed toward rocket motors with multi-million-pound thrusts.

The in-between range of rocket engines also produced by EXCELCO include RV-A-10, Sergeant, Air Force-ReEntry X-17, Polaris-ReEntry X-36, Jupiter Jr., Jupiter Sr., Polaris O, Polaris A, Polaris AIX, Polaris A2-MOD 1-2-3, Nike Hercules, Nike Zeus, Minuteman, Pershing, N.A.S.A. Programs, Scout and Little Joe.

This skilled organization takes everything in its stride—large or small—maintaining its reputation for completion of every job in the shortest possible time.

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**EXCELCO DEVELOPMENTS**
MILL STREET • SILVER CREEK, NEW YORK



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**New**
**Improved**
**Lino-Writ 5**

**Use it as**
**a direct**
**writing paper**
**or develop it**
**with new**
**processing kit**

Lino-Writ 5, proved the most dependable direct writing photo-recording paper you can use, now adds a new bonus: you can use it as a completely dry process paper, or you can process it, for permanent trace results, with Du Pont's new Direct Writing Paper Processing Chemicals Kit.

Improved Lino-Writ 5 is still outstanding for dry-processed image stability and requires no stabilizing treatment for handling under normal room light conditions. Records may now be processed for greater permanence, for making reproductions with diazo equipment or for handling for prolonged periods under intense lighting.

Improved Lino-Writ 5: up to 100,000 ips... easy-to-read traces ... and now, use it either dry or wet process.

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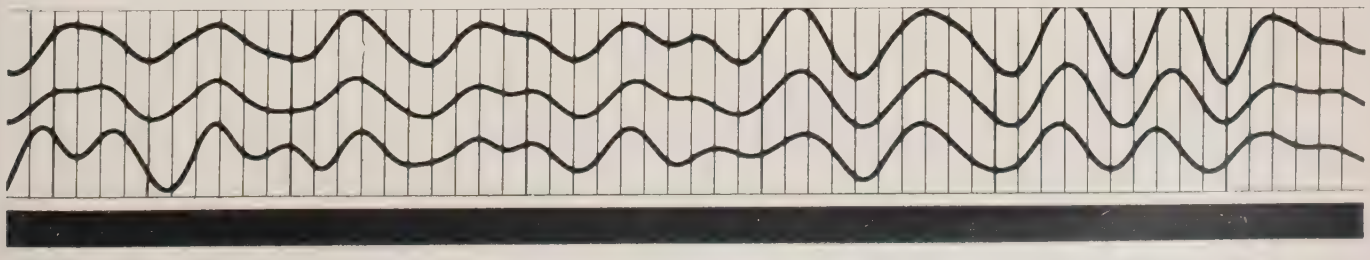

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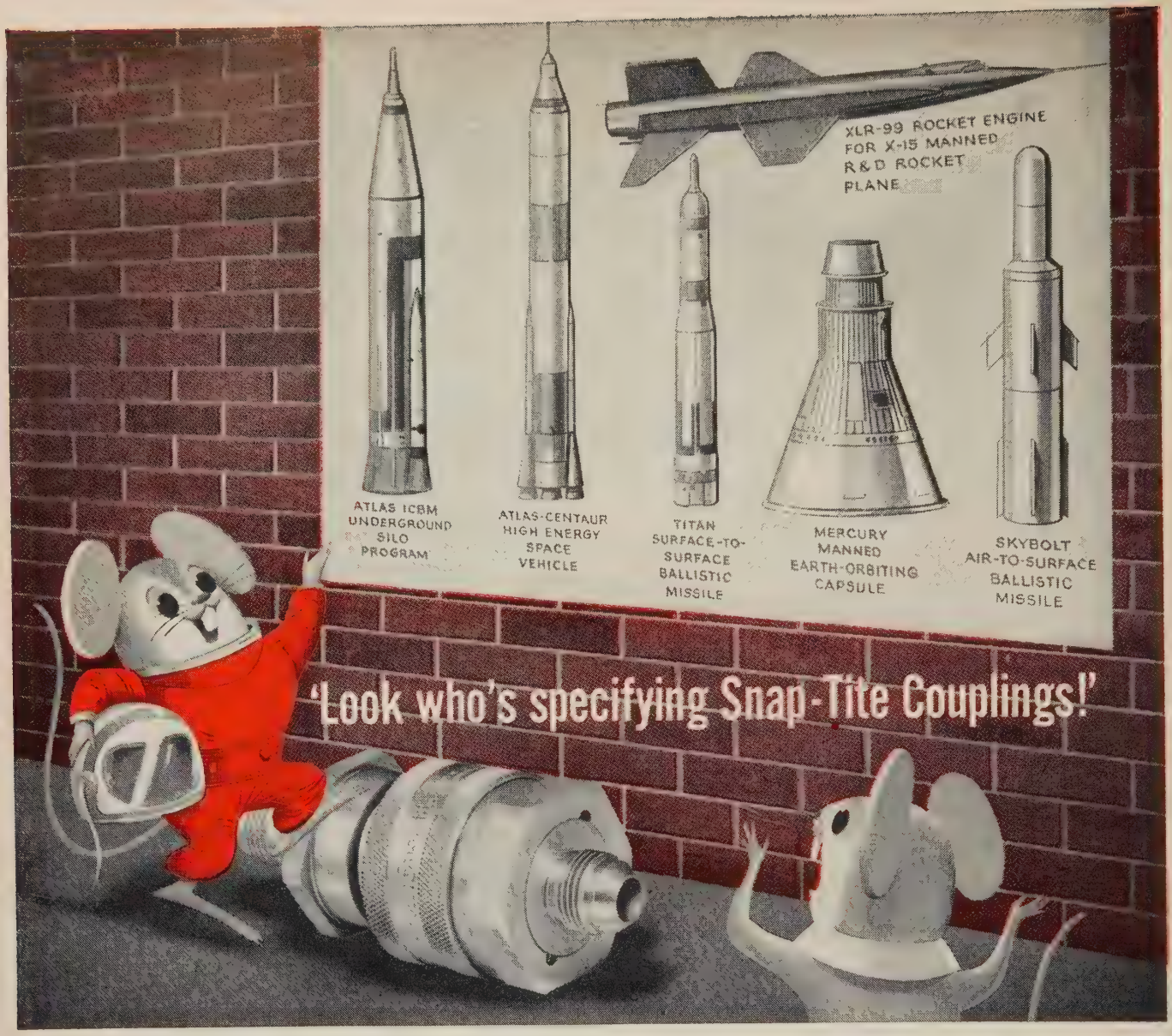
XLR-99 ROCKET ENGINE FOR X-15 MANNED R&D ROCKET PLANE
ATLAS ICBM UNDERGROUND SILO PROGRAM
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'Look who's specifying Snap-Tite Couplings!'

# WHATEVER THE FLUID ... FUEL, CRYOGENIC, HYDRAULIC OR PNEUMATIC ... SNAP-TITE COUPLINGS CAN HANDLE IT

Missile or space vehicle fluid—in fact almost anything that flows—can be (and is) handled through Snap-Tite quick connect, quick disconnect couplings, without contamination or loss.

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**Said Gaspard de Coriolis:** *"A particle which is subject to no forces in a rotating coordinate system experiences a radial acceleration and a tangential acceleration."*

It was around 1840 that Coriolis discovered what has since become known as the Coriolis Effect. He noticed objects above the earth tend to rotate relative to the earth's rotation...to the right in the northern hemisphere, to the left in the southern.

The Coriolis Effect is in force in outer space, too. If a space vehicle is rotated in order to establish artificial gravity, the necessarily short radius of the rotation causes a Coriolis force. This creates orientation problems for a human occupant. To eliminate this difficulty, a scientist at Lockheed Missiles & Space Company conceived the idea of connecting the vehicle to an auxiliary fuel tank by a half-mile-long cable. Thus, if the whole system is then rotated at a reduced speed around its center of mass gravity, the longer radius greatly minimizes the Coriolis force. Right now—on the drawing boards at Lockheed—is an enormously advanced space vehicle system which utilizes this concept, in addition to many others.

Fortunately, natural laws are about the only restrictions which circumscribe scientists and engineers at Lockheed Missiles & Space Company. The climate in Sunnyvale and Palo Alto, on the San Francisco Peninsula, is close to perfection. The creative atmosphere—the opportunity to work on such important projects as the DISCOVERER and MIDAS satellites, the POLARIS FBM, or even more advanced concepts such as the space system cited above—is the dream of the creative engineer.

Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-11A, 962 West El Camino Real, Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required. An Equal Opportunity Employer.

## LOCKHEED MISSILES & SPACE COMPANY

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Systems Manager for the Navy POLARIS FBM and the Air Force AGENA Satellite in the DISCOVERER and MIDAS programs. Other current programs include SAINT, ADVENT and such NASA projects as OGO, OAO, ECHO, and NIMBUS.

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# A look at what's ahead in the realities of space exploration

*Some predictions from Douglas —the company that has helped launch 70% of all U.S. satellites & space probes*

Our mastery of space has advanced so rapidly that only diehard pessimists doubt the moon and planets will know our footsteps within a few decades.

Already a vehicle capable of orbiting a 19,000-pound payload, or driving 5,000 pounds to escape velocity, or lofting 2,500 pounds to Mars or Venus is being built in the U.S. This is Saturn, taller than a 14-story building, with an initial thrust of 1.5 million pounds. Its second stage, under construction for NASA by Douglas, will use a cluster of liquid hydrogen-oxygen engines of unique design.

The world knows a man can rocket into space and return. Can he survive for long periods? Douglas studies give a strong affirmative. Zero gravity and artificial G require further study. Radiation is a continuing problem, but reports from Discoverer XVII, one of 46 space projects launched by the Douglas Thor rocket, show the threat less serious than was first thought.

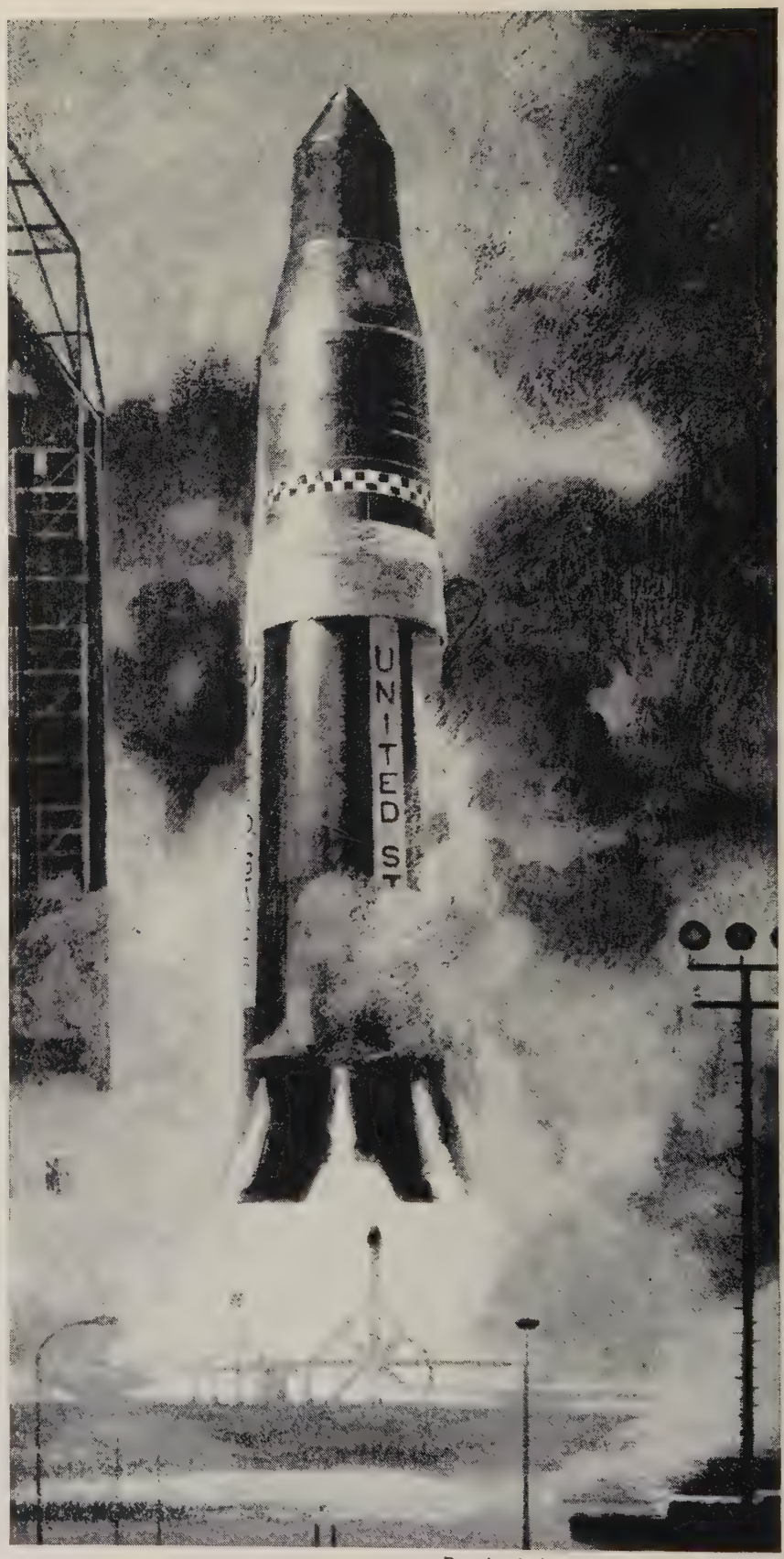
The cost of space travel? A breakthrough in nuclear power, which Douglas engineers confidently predict, should cut the operational cost of a trip to the moon to about $900 per passenger. Other power sources, already under study, may even open such stars as Sirius and Alpha Centauri to travel.

**The DC-8 Jetliner, an example of Douglas aero-space leadership**

Few of us will ever be lunar commuters, but growing millions are learning about a new kind of travel through the DC-8 jet.

Here is an airplane that slices through time at 10 miles a minute, opens the world to all who have an urge to get up and go places.

Next trip, fly a DC-8 jet, newest of which is the DC-8 Series 50, fastest long-range jetliner in the sky.




Douglas is building Saturn's 2nd stage.

DOUGLAS

DOUGLAS AIRCRAFT CO., SANTA MONICA, CALIFORNIA • MAKERS OF MISSILE AND SPACE SYSTEMS • MILITARY AIRCRAFT • DC-8 JETLINERS • AIRCOMB® • RESEARCH AND DEVELOPMENT PROJECTS • GROUND SUPPORT EQUIPMENT • ASW DEVICES



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# LOWER COST-PER-LANDING

## ANOTHER REASON WHY MOST JETS RELY ON

# BENDIX® BRAKES

One airline averaged per-landing brake costs of only 86.7¢ in 30 months with Bendix. Another line reports 85¢ cost-per-landing in 30 months. Figures like these show why many jets today rely on brakes by Bendix—world's most experienced brake manufacturer. These dependable units also give improved pilot control and greatly reduce turn-around time.

**Bendix Products Division**

The Bendix Corporation

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# rockets and missiles

On the drawing boards, under development and in production, our country has a vast array of rockets and missiles. Some designed for offense, others for defense and many adapted for pure astronautical research. Kelsey-Hayes plays an important role as a subcontractor in this dynamic space program and has developed highly trained personnel and facilities for design, research and production. Kelsey-Hayes Company, General Offices: Romulus, Michigan.

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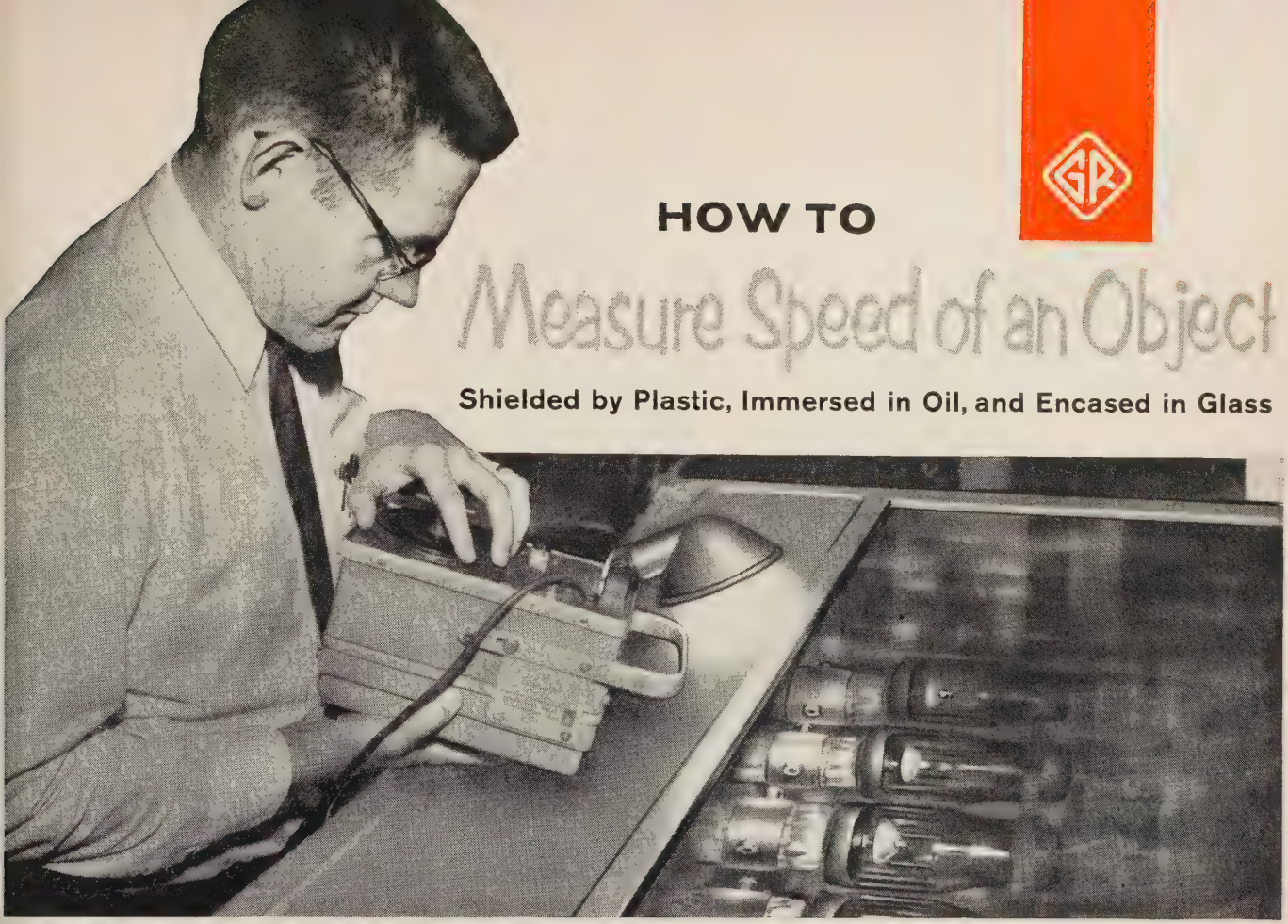

# HOW TO Measure Speed of an Object

**Shielded by Plastic, Immersed in Oil, and Encased in Glass**

Engineers at the Machlett Laboratories were faced with a perplexing problem — how to measure the speed of their new 10,000-rpm, rotating anode Dynamax "50A" X-Ray tube while immersed in oil. For many years, stroboscopic equipment had been used to measure anode speeds of approximately 3600 rpm, but older stroboscopes did not produce sufficient light intensity at the higher operating speeds of newer X-Ray tubes.

The recently announced Type 1531-A Strobotac solved Machlett's problem. This new design with its intense *white-light* and concentrated "long-throw" beam easily pierces the plastic cover shield, the oil, and the tube's glass envelope at rates as high as 25,000 flashes per minute. Measurements are made without need of auxiliary equipment or direct electrical or mechanical connection to the object under test.

## Type 1531-A STROBOTAC®

## Electronic Tachometer and Motion Analyzer

**...$260**

. . . an important aid in the development and test of motors, synchros, loudspeakers, relays, vibrators, acoustical equipment, and countless other electrical and electro-mechanical devices.

**Flashing-Rate Range:** 110 to 25,000 flashes per minute direct-reading; useful for speed measurements to 250,000 rpm.

**Flash Duration:** 0.8, 1.2, and 3.0 millionths of a second for high-, medium- and low-speed ranges, respectively. Short duration eliminates blur when observing rapidly moving parts — lets you study details previously impossible to see.

**Accuracy:** ±1% of dial reading — permanently assured by neon-bulb calibrator on instrument panel.

**Bright White Light:** 0.21, 1.2, and 4.2 million beam-candlepower (minimum) on high-, medium-and low-speed ranges, respectively. Long-throw beam reaches deep into machinery innards, enables measurements under normal room lighting.

**Easy to Use:** simplified range switch . . . pivoting lamp . . . carrying case provides protection and doubles as an adjustable bench stand . . . light weight and compact, only 7½ pounds . . . can be triggered with an external mechanical contractor or 6-volt peak-to-peak signal . . . can be operated from a 105-125 or 210-250 volt line, 50-60 and 400 cycles.

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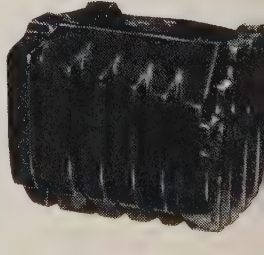
No. 20 on Reader Service Card

# BFG FUEL CELLS FIT T-38 LIKE A GLOVE TO INCREASE RANGE

To maximize the capacity of the five internal fuel cells of the Northrop T-38, every bit of available space has to be utilized. Thus B.F.Goodrich builds the cells in a complex configuration—rather than the usual flat surface—to fit around structural members and other equipment.



These BFG cells are produced to very close tolerances to provide a fuel-tight system with proper fit. This close quality control has simplified Northrop's assembly operations. And as an added bonus, BFG developed a new fitting which reduces over-all fuel cell weight.

B.F.Goodrich maintains complete fuel cell test and development facilities . . . and has extensive experience in design and production of cells for aircraft, missiles, and ground vehicles. For complete information contact B.F.Goodrich Aerospace and Defense Products, a division of The B.F.Goodrich Company, Dept. SA-11, Akron, Ohio.

**B.F.Goodrich** **aerospace and defense product**



No. 21 on Reader Service Card

## *Users want to know*

WE'D LIKE to call your attention to a box appearing on page 106 of this issue, as part of our special state-of-the-art report on infrared detectors. Even if you couldn't be less interested in infrared, we think you'll be interested in this box.

Based on a survey by Associate Editor Bern Kovit, this box presents a series of questions asked by users of IR detectors and the answers to them by detector manufacturers. We have two reasons for believing it to be so important:

- The questions are the questions that are perhaps most important to any working engineer—How much better will future equipment be? How much more will I have to pay for it? What happened to that device that was predicted with such fanfare two years ago and hasn't been heard of since? Has research in that and that direction really hit a dead end? And the answers were answers, straightforward and informative.
- Despite their importance to him, these are the questions to which the average engineer finds it hardest to get the answers.

MOST OF the manufacturer's information reaching the users of aerospace equipment is information that a manufacturer wants the users to know —not necessarily information that the users want to know. This second kind of information isn't thrown at the engineer in articles, papers, brochures, and what have you. He's got to go out and get it—by making field engineers' lives miserable, by writing or phoning all over the country, by buttonholing other engineers in chance encounters, by burrowing through the literature for stray data that, with strong doses of extrapolation and guesswork, will yield a basis of comparison, and finally, in desperation, by running his own test program.

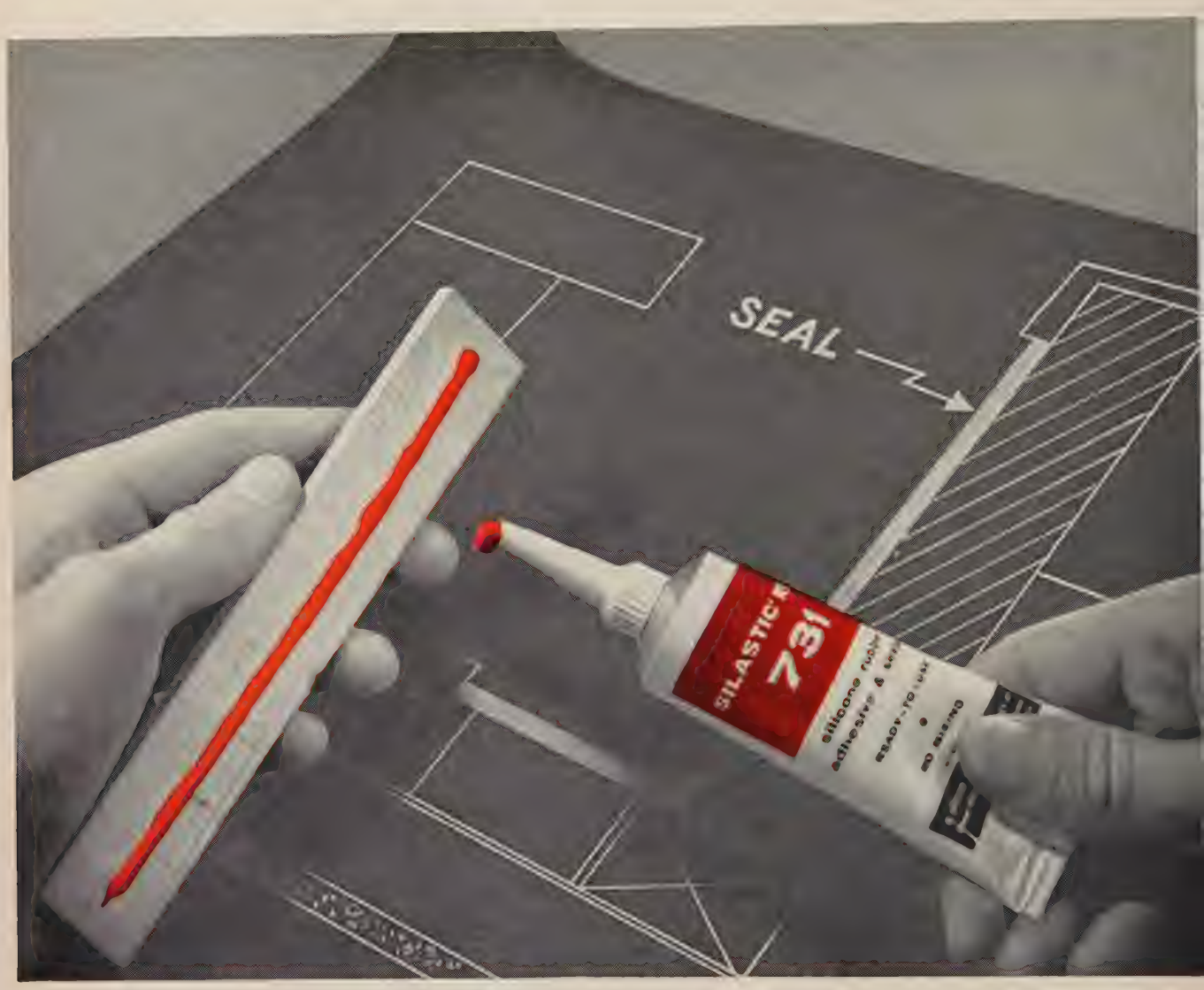
None of these methods is really efficient, in terms of the time it takes or the results it gives. But what alternatives are there?

MAGAZINES like ours can help, as Bern Kovit has shown, and we certainly will do what we can. But we can't do the whole job. We haven't got a monopoly of information. (There's too much information, and monopolies aren't nice.)

Actually, the biggest help, as so often, would be self-help. There are all those technical meetings whose steady increase is upsetting everybody. If the engineers who use aerospace equipment started agitating for time at these meetings during which groups of users and groups of manufacturers could get together to discuss questions previously submitted by the users, we'd kill two birds with one stone—the users would get the answers to questions they rarely get answered otherwise, and the meetings would have been made more useful.

True, a few papers might have to go unread. But that's a loss we should manage to survive.

# Stops leaks permanently

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# Washington Briefing

- ► USAF Plans Stepped-Up Space Program
- ► DOD Wants More Interservice Mergers
- ► A4D-Type VAX to Fill Troop Support Gap

**The newest Pentagon-White House public education campaign** involves efforts to step up the military space program. USAF officials are working with Dr. Edward C. Welsh, executive secretary of the National Aeronautics and Space Council, on ways and means to convince the public and Congress that more money will have to be added to the military budget for space activities in the fiscal 1963 budget.

Although emphasizing that he speaks for himself and not the NASC as such, Dr. Welsh is already on record with these points:

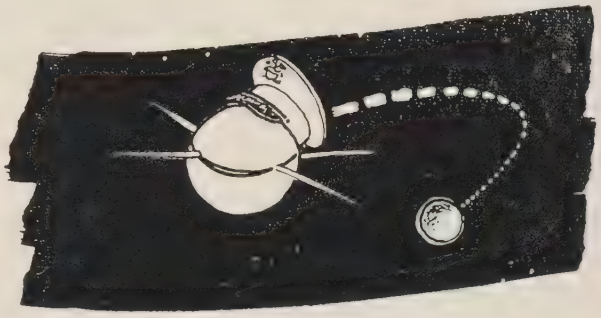
- The U. S. is in a space race with the Russians and any other pretense is "absurd." The contest is not just for the fun of racing. It involves this country's struggle for survival.

- Even if Russia were not involved, the U. S. should be making a vigorous space effort. "The potential benefits . . . are so great that we have no right to deprive our children or future generations of them, regardless of what the Communists decided to do."

- Return on the U. S. space effort will exceed costs many times over. Advantages will come in education, medicine, metallurgy, international prestige, defense against aggression, and in higher living standards.

In making these points before the annual meeting of the Air Force Association in Philadelphia late in September, Dr. Welsh emphasized that the military and civil space programs could be handled at a cost of about one percent of the gross national product, or an average of five billion dollars a year, over the next five to seven years.

Dr. Welsh's views, despite his disclaimer, pretty well reflect the thinking of the five members of the **Space Council** (Vice President Lyndon Johnson, Defense Secretary Robert McNamara, NASA Administrator James Webb, AEC Chairman Dr. Glenn Seaborg, Secretary of State Dean Rusk)

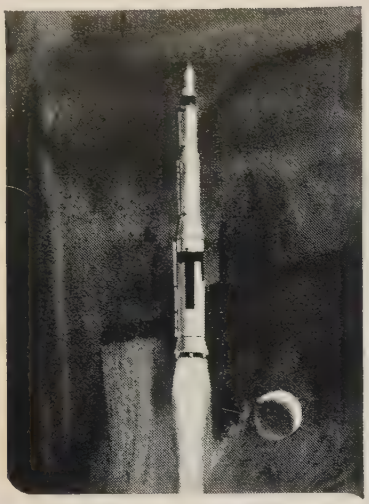


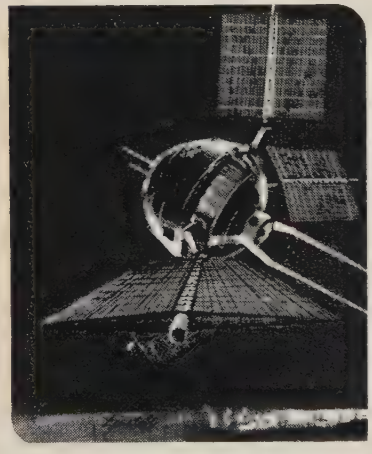
about the need for a buildup of military space projects.

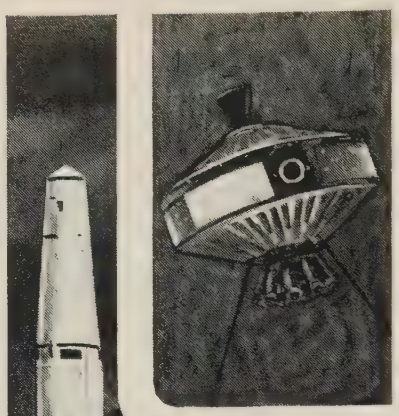
The new emphasis on military space operations will become apparent when the 1963 budget is submitted to Congress. Gen. **Bernard A. Schriever,** commander of the Air Force Systems Command, is now working up a combination of new projects he considers vital, including:

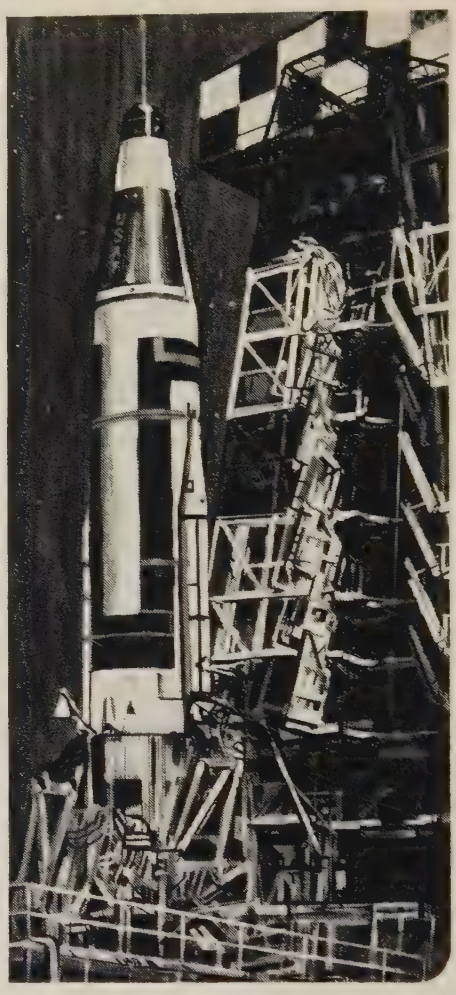
- A greater emphasis on manned spacecraft.
- The ability to place large payloads in space.
- The ability to navigate and maneuver spacecraft.
- Means of entering space and return-

# CAREERS IN SPACE TECHNOLOGY LEADERSHIP









Of particular interest to engineers and scientists is the continuing growth and diversification of Space Technology Laboratories, Inc. What is now STL was founded as the Guided Missile Research Division of the Ramo-Wooldridge Corporation in 1954, when the Ballistic Missile Program was given highest national priority. ■ Assigned contractual responsibility for the program's systems engineering and technical direction, STL has grown in parallel with the need for its capabilities—from a small group of engineers, scientists and administrators to an industrial organization with a professional staff numbering more than 2,000 with 2,500 supporting personnel—from its initial headquarters in a suburban Los Angeles schoolhouse to the ultra-modern STL Space Technology Center nearing completion on a 110-acre site at One Space Park, Redondo Beach, California, close to Los Angeles International Airport. ■ During its years of Space Technology Leadership, STL has contributed importantly to the management of a program that, in a successful race against time, has given this nation the Thor, Atlas, Titan and Minuteman ballistic missile systems. At the same time, STL has been called upon to design, fabricate, instrument and successfully launch Pioneer I, Explorer VI and Pioneer V—all of which were tracked and commanded by STL's world-wide space communication network (SPAN)—and to contribute to the management of the Transit 1B, Transit 2A, Transit 3B, Courier 1B and Tiros programs. ■ Today, STL in addition to its continuing role in the USAF Atlas, Titan and Minuteman programs, is performing research, development, design and construction for three Orbiting Geophysical Observatories (OGO), as well as project coordination and systems planning for Project Relay, both for NASA; and participating in the Army Advent communication satellite project. STL's continuing program of original and applied research covers a broad spectrum of technical disciplines including particle physics, solid state theory, guidance space physics, communication theory, propulsion and power, and electromagnetic systems in the infrared, ultraviolet and microwave regions. ■ The expanding activities of STL create immediate career opportunities in Southern California and at Cape Canaveral for engineers and scientists of talent and vision. All qualified applicants are invited to communicate with Dr. R. C. Potter, Manager of Professional Placement and Development. STL is an equal opportunity employer.

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ing to earth at times and places chosen to support a selected mission.

- Ways of rendezvousing in space to refuel and/or transfer cargo.
- The ability to observe, inspect and, if necessary, neutralize satellites.

Exactly what the price tag of the various new AFSC space projects will be is still unknown, and nobody knows how much of the Schriever space package the AF, DOD, and the Budget Bureau will approve.

But there is little doubt that Congress next year will give an expanded military space program the same approval it gave the revised Kennedy-NASA "man-on-the-moon by 1970" project this summer.

■ ■ ■

**Merger of USAF's Tactical Air Command** with the Army's Strategic Army Corps (STRAC) under Army Gen. Paul D. Adams is just a forerunner of other combined commands.

Defense Secretary **Robert S. McNamara** and his deputy, Roswell L. Gilpatric, have given the Joint Chiefs of staff and other high-ranking officers several study problems involving merged operations. The questions are usually put this way: "If this organization and the similar one in one of the other Services were combined, how would the merged group operate?"

The military then comes up with its impressions of how effective or ineffective the combined command would be and McNamara and Gilpatric decide on the next step.

This was the pattern in the TAC-STRAC merger. Comparable studies are now under way on a joint USAF tanker command, whose KC-135 jet tankers would service not only the B-52s and B-58s in the Strategic Air Command, but also the F-100s and F-105s in TAC. Under the present setup, SAC has its own KC-135s and TAC uses older and slower KB-50J piston-powered tanker planes that have two jets mounted for auxiliary power. If and when a combined tanker command is ordered for the USAF, it would mean additional procurement of KC-135s. SAC has been buying two tankers for every three B-52s. A combined tanker command would start off with KC-135s and KB-50s. But as Gen. Frank F. Everest, who just retired as TAC's commander, put it, "time is running out" on the KB-50. Everest, making a plea for KC-135s for TAC, points out the jet tanker not only increases deployment speed but also reduces and sometimes eliminates the need for prepositioning tankers along overseas routes.

Another combined operation under intensive study at McNamara's order is a U. S. Strategic Command, which would have jurisdiction over bombers (carrier or land-based) and IRBMs and ICBMs (U. S., submarine or foreign - soil launched). Such a proposal was first made by SAC's Commander, Gen. Thomas Power, two years ago and has been resisted by the Navy.

■ ■ ■

**McNamara's insistence** on a single tri-service fighter to support ground troops has been effectively abandoned. Navy and USAF have agreed in principle on a TFX design, but there are still so many differences between the two services' size and weight requirements that Washington skeptics are convinced the TFX will come out as two different airplanes. Meanwhile the interim VAX airplane will be procured to fill the troop support gap.

The VAX is to be an aircraft somewhat like the Navy A4D. It will have Army requirements cranked into its design, will be procured by the Navy and operated by the Air Force (TAC) in support of the Army and by the Navy in support of the Marines.

Another project pushed by McNamara is the tri-service VTOL transport. Winner of the competition on this aircraft was the team of **Vought, Hiller** and **Ryan.** The Navy was originally scheduled to be the monitoring agency, but the winning design does not meet Navy specifications and the USAF has taken over cognizance.

# AEROSPACE

## *Air Force Has Wide-Ranging Plans for Next Year's Budget*

| What They Want for FY '63 | |
|---|---|
| Air Force | rail Minuteman<br>more cargo and tactical planes<br>military man-in-space projects |
| Navy | more Polaris subs |
| Army | Zeus production |

Military planners are putting the finishing touches on their proposals to Pentagon comptroller Charles Hitch and Budget Director David Bell for the fiscal '63 defense budget.

The Air Force apparently is seeking reinstatement of the rail-launched Minuteman missile (which was deferred by Defense Secretary Robert McNamara and President John F. Kennedy in their first revision of the current budget) and wants to beef up our airlift and tactical-aircraft programs. The Navy is pushing for more submarines to carry the Polaris, including the 2500-mile A-3, and will undoubtedly succeed. The Army's continuing effort to get the Nike-Zeus into production, however, seems destined to be thwarted, at least until next year's tests against Atlases at Kwajalein Island.

Commenting on the Air Force's position on tactical and airlift forces, Maj. Gen. David A. Burchinal, USAF Director of Plans, said, "We know from experience that modernization must be continuous. It may be that augmentation will also be required." This means that USAF is thinking of buying more Lockheed C-130s and C-141s and Boeing C-135s as well as of new development programs for successors to these cargo planes. Even though the TAC and the Army's Strategic Army Corps have been combined, USAF is obviously programing a large-scale procurement program for turbine-powered cargo aircraft in fiscal '63.

**Dyna-Soar and B-70 Boosts?** Two other projects that USAF has been pushing hard, Dyna-Soar and the B-70, may also be due for acceleration—if McNamara and his deputy, Roswell L. Gilpatrick give their O.K. Gilpatrick has already said that "defense expenditures for the foreseeable future are likely to remain in the $50-billion-a-year range . . ." Whether this figure takes Dyna-Soar and the B-70 into account is not yet known. It certainly does cover a big step-up in military space research.

USAF's Systems Command is readying proposals involving military man-in-space projects. All indications are that these will be accepted for inclusion in the budget to be submitted in January.

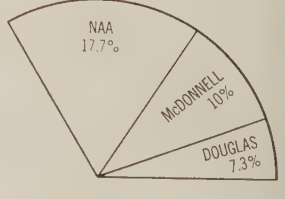
**Logistics Management** The Pentagon is planning to step-up its use of universities and non-profit organizations for military research and operations planning. Despite some eyebrow-raising on Capital Hill about the continuing employment of these organizations, DOD has decided to employ outside consultants for logistics management.

The military spends about half of the defense budget on logistics management. It hopes a new full-time agency will achieve as many breakthroughs in logistics as some non-profit technical organizations did in weapon technology.

The new organization will be the Logistics Management Institute (LMI) and will be headed by Charles H. Kellstadt, board chairman of Sears Roebuck. A non-profit fact-finding and research body it will be guided by a nationally known board of trustees made up of nationally known figures. DOD will support LMI through contracts, and the new agency will work with industry organizations—like the National Security Industrial Association and the Electronic and Aerospace Industries Associations—and with the service-supporting groups (Air Force Association, Navy League, Association of the Army).

**Top NASA Contractors** Not surprisingly, many leading Pentagon contractors play the same role in NASA's operation, but there are also quite a few who don't. Included in DOD's traditional contractor ranking but not among NASA's top 20 are companies like Boeing, Martin, Republic and United Aircraft.

NASA let $423 million to contractors in fiscal '61. (Additional NASA cash went to industry through other agencies.) About 83 per cent of the contracts were cost-plus-fixed-fee types. The leading contractors were: NASA (75 million), McDonnell ($42 million), Douglas ($31 million), Western Electric ($27 million), STL ($13 million), Chrysler ($13 million), Grumman ($11 million), Hayes ($10 million), GE ($9 million), Chance Vought ($9 million), RCA ($8.5 million), Bendix ($6.5 million), Aerojet ($6.3 million), Lockheed ($3.3 million), and General Dynamics ($2 million).




**Space Flight Lab** After a prolonged search, NASA picked a 1000-acre site in Houston, Texas, for its new $60 million manned space flight lab. Many influential members of Congress—which authorized the project for the current fiscal year—now want to be certain the lab will not duplicate existing facilities. Members of the House Space Committee are concerned about the possibility that the Houston lab will contain much equipment already in existence at Wright-Patterson AFB Dayton; the Navy facilities at Johnsville, Pa., and Pensacola, Fla., and USAF facilities like the School of Aviation Medicine.

NASA visualizes the space flight lab as the command center for manned lunar launchings and all follow-on space flight missions and plans to use it for the design development, evaluation and testing of the Apollo spacecraft and its subsystems. The lab will include four integrated facilities: a flight project facility, an equipment evaluation building, a flight operations plant, and an environmental testing lab.

# INTELLIGENCE

The three-man Apollo will be built at the Michoud plant in New Orleans, La., and launched from the expanded launch site at Cape Canaveral, Fla. Like the Houston lab, both these installations are accessible by deep-draft vessel—a prime requirement, according to NASA.

## *Hughes Cesium-Ion Engine One of Four NASA Electric Rockets*

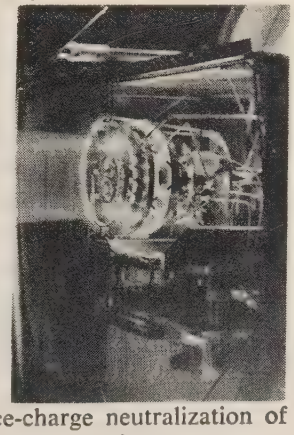
Details of its NASA-sponsored program were disclosed by Hughes Aircraft, whose design is one of four electric propulsion systems slated for flight tests beginning in late '62. Ion engines being developed by Electro-Optical Systems (for USAF) and NASA-Lewis and a Giannini Plasmadyne engine are the other three designs.

Dr. Ernest Stuhlinger, of NASA-Huntsville, told SPACE/AERONAUTICS that lab tests and extensive theoretical analysis of current ion engine designs show that the neutralization problem, once considered a stumbling block that might rule out an operational ion rocket, has just about disappeared (though we can't be absolutely sure until an ion engine has actually been tested in outer space). The importance of the ion engine for deep-space research, Stuhlinger noted, is shown by the case of a space probe sent to the vicinity of Pluto, 3.7 billion miles away from the earth. A chemically powered probe, he said, must travel on a Hohman ellipse and would take about 45 years. An ion engine would get the probe to Pluto in "only" three years.

Present plans call for a four-stage Scout for the '62 flight tests. Its payload will have two ion engines, mounted on folding arms. The payload will be spin-stabilized; when the ion engines are energized, they will change the spin rate, from which the thrust will then be deduced on the basis of telemetered data. The two ion engines will fire alternately.

The Russians, Stuhlinger notes, seem to be well aware of the importance of ion engines also. They had their first lab model of an ion engine working in late '57 or early '58, he says. The first U. S. unit ran in the summer of '58 (at Rocketdyne).

**Neutralized Cesium Ions**



Hughes' ion engine uses cesium as its propellant, stored in a reservoir from which cesium vapor is diffused through a hot tungsten element, which ionizes the cesium by contact ionization. A system of electrodes then applies voltage to accelerate the ions to a very high exhaust velocity. The high-velocity ion beam passes through a neutralizer region, in which electrons are injected into it to provide space-charge neutralization of the electric field of the positive cesium ions.

The once-feared neutralization problem is posed by the fact that electrons must be emitted at the same rate as ions. If only positive ions were ejected, the vehicle would charge up negatively until it pulled the ions back. Getting a proper electron-ion balance has been complicated by the disparity in mass—a cesium ion has more than 250,000 times the mass of an electron.

Hughes uses a precisely defined arrangement of electron emitters and auxiliary electrodes immediately behind the exit electrode of the acceleration chamber. This design generates an electron trap within the ion beam, providing a self-adjusting reservoir of electrons uniformly distributed over the beam cross-section, according to Dr. M. R. Currie, of Hughes Research Labs.

**60-kw Reactor** Primary energy source for the Hughes ion engine will be a nuclear reactor. The initial system being developed by NASA and AEC will generate up to 60 kw for up to a year. Boosted into space by an Atlas-Centaur in '66 or '67, it is expected to be suitable for a 100-lb Mars, Venus, or deep-space payload.

The principal goal of NASA's program, Stuhlinger stated, is to send a manned vehicle to Mars. For this, a nuclear-electric system providing 15-20 Mw must be developed. With such a system, a vehicle would need about 200 days to reach Mars from an orbital station and about as much for the return trip.

Present ion engine thrusts are measured in millipounds. By '65, Currie believes, clustered engines with thrusts of several tenths of a pound and operating efficiencies of over 85 per cent can be ready for flight test, if intensive development work is done on them. In a typical design based on the nuclear Snap 8 generator, 10 ion engines would be mounted in a triangular arrangement measuring four feet on a side.

**Ablative Rocket Chamber** Ablative thrust assembly designed by United Technology for 3300-lb-thrust liquid rockets is filament-wound and weighs 30 lb. Thrust chamber and exit cone are 28 in. long overall; exit cone is 13.05 in. in diameter at its widest point. A 2200-lb-thrust model has been continuously test-fired for 4.5 minutes.

**Strength of Iron Whiskers** New apparatus and methods for finding the tensile strength of iron whiskers were disclosed by J. E. Emrick, of ASD's Metals & Ceramics Lab. At present, there is no commercial equipment that will measure this property.

In the tensile tester designed by ASD, the load is applied to the specimen by the extension of a calibrated spring that is attached to the end of a depth micrometer by a ball bearing joint. Strain is measured by optical observation of the differential movement of two gage marks attached to the whisker specimen. The gage marks are made by attaching small bits of whiskers to the specimen with a special rosin mixture. A projection system throws a magnified shadow of the gage marks on a ground-glass screen behind a measuring scale.

Emrick reports that iron whiskers grown from the re-

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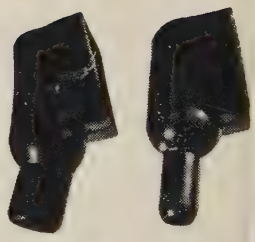

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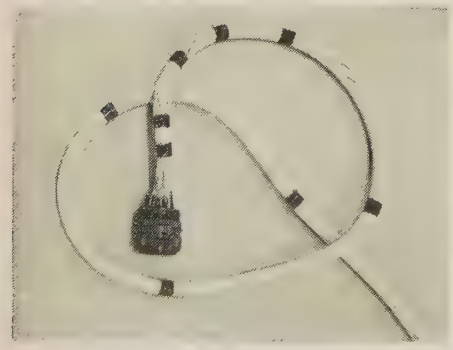

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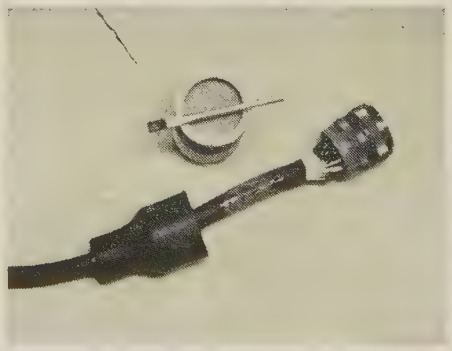

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duction of ferrous chloride in a 97 per cent hydrogen atmosphere had very low strengths—on the order of 20,000-100,000 psi, or 14-70 kg/mm$^2$. Whiskers grown in an argon atmosphere contaminated with 0.1 per cent hydrogen were five microns or less in diameter (against 10-50 microns for the other whiskers) and had strengths averaging better than 350 kg/mm$^2$. Some went as high as 1100 kg/mm$^2$. This corresponds to 500,000-1,500,000 psi and is in line with previously reported high iron whisker strengths.

**First Saturn Launch** The first experimental launching of the Saturn's S-1 first-stage booster, slated for late last month, was planned by NASA with the objectives of testing the S-1 propulsion system, verifying the aerodynamic and structural design of the entire vehicle, and proving the design concepts and operation of the support equipment. Dummy S-IV and S-V upper stages and an inert payload were to be carried into a short trajectory of about 225 miles, with a peak altitude of about 90 miles. The flight was expected to last about eight minutes, and the vehicle was to reach a speed of 3700 mph.

Overall, 10 R&D firings are scheduled for the Saturn C-1 program. They are expected to result in an operational C-1 in '64 and an advanced version somewhat later. The C-1 will be the launch vehicle for the earth-orbiting three-man Apollo, while the improved rocket is to be used for boosting a three-man crew into a lunar orbit.

The first Saturn (designated SA-1) is 162 ft. high and will weigh about 925,000 lb at lift-off. Its first stage will be powered by eight Rocketdyne H-1 motors with a total rated thrust of 1,300,000 lb. Starting with the fifth launch, the motors will be rated at 1,500,000 lb total.

**Centaur Scratched for Mariner** Delays in the development of the liquid-hydrogen and lox Centaur prompted a change in plans for the Venus probe scheduled next year—an Atlas-Agena-B will be used in place of an Atlas-Centaur. The switch to the less powerful Agena stage means that only a 400-lb payload can be sent up instead of the 1100-lb JPL Mariner package as scheduled.

The Centaur program, which called for flight-testing by the end of this year, has fallen about five months behind. If the Venus probe is not launched as planned next year, it will be two years before the planet is again in as favorable a position for the mission.

**Second Zeus Abort** A Nike-Zeus exploded only a few seconds after launching in the anti-missile missile's second failure in a month. The Zeus is programed to destroy itself in the first sixteen seconds of flight if there is a significant variation in speed or direction from the flight plan—a necessary precaution in view of the missile's very high initial speed (as much as 2600 mph at launch).

Other recent missile tests were more successful:

- A Titan I was fired from a hardened silo at Vandenberg AFB, Calif., and went 4500 miles down the Pacific Missile Range to the target area. The 110-ft ICBM was raised from its 165-ft-deep silo and fired two minutes after it had reached the surface.
- A Polaris A2 was boosted out of a tube on the deck of the USS Observation Island with compressed air in simulation of a sub launching. The first-stage motor ignited about 70 ft above the deck and the second stage a minute later, carrying the solid-propellant missile over its full design range of 1500 miles. Three previous attempts to launch the A2 from the Observation Island had failed. Lockheed, which makes the Polaris, has said that the failures were due to cracking jetavators on the first-stage engine.

**How Titov Landed** As described by T. Malinovsky in *Kommunist Moldavii* and translated by the Office of Technical Services, the Vostok II used "compressed gas in tanks on the outer surface of the ship" that was "released by command from the earth to give the vehicle a rotational moment to properly orient it before the jet braking mechanism was switched on. The command for descent was given on the eighteenth revolution. The descent was begun at a distance of 11,000 km [6820 miles] from the point of landing and continued to an elevation of seven kilometers [4.34 miles] above the earth's surface, at which point the capsule . . . was catapulted. The deviation of the ship and its cabin from the projected landing site did not exceed 10 km [6.2 miles]."

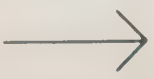
**Blue Streak Based on Atlas** Blue Streak, Britain's first stage for a projected multi-national European spacecraft generally is based on the Atlas. A thin-gage stainless-steel tank, stiffened by pressurization, forms the main structure. The power-plant consists of two gimballed Rolls-Royce rockets based on Rocketdyne designs.

The dry weight of the entire stage is seven tons; the launch weight weight, 92 tons. A thrust of 300,000 lb or more is expected.

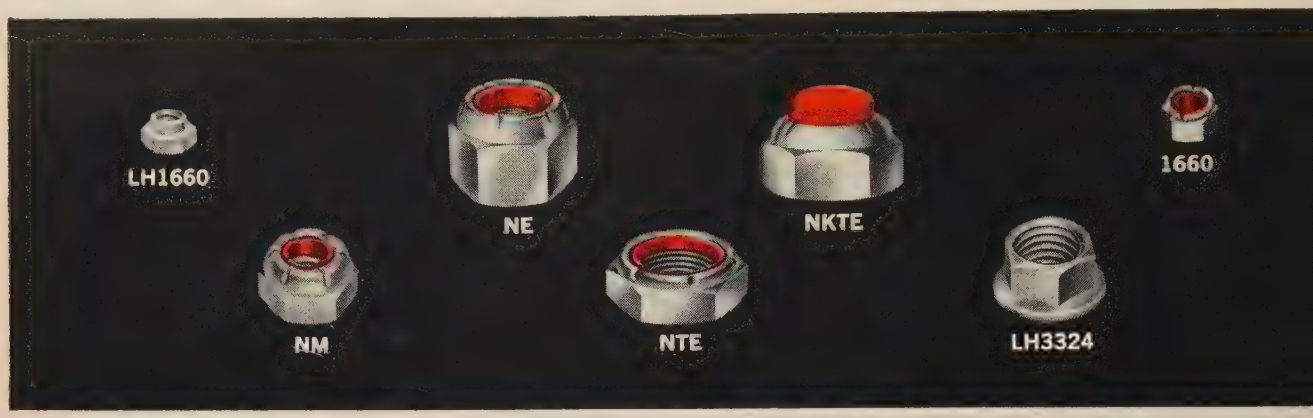
**X-15 Record Flights** New altitude and speed records were set by the X-15 as its test program continued. On October 11, Major Robert M. White, USAF, reached 217,000 ft and 3647 mph. The current official speed mark, however, had been set exactly a month earlier when Joe Walker, senior NASA test pilot got up to 3645 mph at 110,000 ft.

White's flight, which had been intended as an attempt at the altitude record and set a new speed figure "accidentally," lifted him above 99.9 percent of the earth's atmosphere. Only the Russian and American astronauts have gone higher. Eventually the X-15 may reach altitudes of as much as 100 miles.

During re-entry into the thicker part of the atmosphere, skin temperatures reached an estimated 900 deg F. In the speed flight, temperatures had gone up to about 850 deg F. Walker described their effects as a "popping and banging" as of "an old stove heating up and cooling down."



# 17 ESNA FASTENER SOLUTIONS FOR HUNDREDS OF ELECTRO-MECHANICAL SYSTEM APPLICATIONS




## HEX TYPES

ESNA hex nut thread sizes range from a miniaturized 0-80 through standard SAE 1½"-12—and up. Designers have a choice of two types of reliable self-locking devices—depending on operational temperatures. Both types have received military approval and most parts are produced in carbon and stainless steels.

For temperatures up to 250° F., the high-reuse nylon insert type is recommended. For temperatures of 550° F. or 900° F. and higher, the all-metal offset closure provides excellent self-locking results. Nylon insert nuts can be reused a minimum of 50 times on a standard screw and still retain locking torque. Nylon will not gall bolt threads or peel cadmium from the screws to foul or short vital circuits. Its dielectric strength and volume resistivity are extremely high. Nylon caps, available in most configurations, prevent "corona" effect, seal bolt ends, protect wires from chafing on bolt edges.

All-metal nuts using ESNA's elliptically offset locking device provide excellent re-usability because of their high hardness.

## CHASSIS TYPES

Clinch types fasten to chassis or console by single hole mounting. Available in standard sizes and in new miniature flush mounting types; both all-metal for 550° F. temperature and with special nylon inserts for 350° F. operating environments. Also a new floating clinch nut which gives the economy of single hole mounting plus float to compensate for minor screw or component misalignment. Both standard and miniature clinch types are available with nylon caps. For other "black box" uses there are miniature right-angle "floaters," heavy duty fixed anchors for drawer slides. There is also type LH4786, a new captive washer electric terminal nut.

The new ESNA catalog no. 960 shows the hundreds of configurations—with nylon inserts, nylon caps, or in all-metal designs—of ELASTIC STOP® nuts that are available as standard parts. Why not send for your copy today? We'll be glad to send sample nuts for testing, too. Just specify type and size. Write: Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey. Dept. S60-1150.

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Cmdr. Forrest S. Petersen, USN, set up skin temperatures estimated at 1000 deg F when he hit 3545 mph on September 28. The intense heat scorched the paint inside the C-15's cockpit and impaired visibility for about 15 seconds.

Another flight on October 4 was made without the ventral fin, in a test of manual control of the plane in case of failure of the automatic stabilization system. Wind tunnel tests had shown that the X-15 would handle best without this fin under such circumstances. Normally the fin is jettisoned by the pilot just before he makes his dead-stick landing.

**RP-76 Tests Ended** Missile target tests of Radioplane's rocket-powered RP-76 drone were completed at Pt. Mugu, Calif., by the Navy. The drones were launched at altitude by F3H fighters 50 miles at sea and were radio-controlled from the Naval Missile Astronautic Center at Pt. Mugu. The RP-76s operated at speeds of Mach 0.9 and altitudes of 40,000 ft and were fired on by Sparrow and Sidewinder air-to-air missiles. The test results show, Radioplane reports, that the RP-76 provide great flexibility as a fleet training aid.

**More Accurate Venus Data** Radar observation of Venus from USSR, V. A. Kotelnikov and I. S. Shklovskiy stated in *Izvestia,* have provided much more accurate data on both the planet and the solar system as a whole. The Russians claim their observations have made it possible to calculate more exactly the dimensions of the solar system and, for the first time, to estimate reliably the rotational speed of Venus. They say that they reached the surface of Venus with radio waves with a power of 15 W and got back much more powerful signals than did U. S. and British researchers in '58 and '59, respectively.

The Soviets gave the difference in radial velocity of different reflecting portions of Venus' surface as about 262.4 fps. Assuming that Venus' axis of rotation is perpendicular to the direction earth-Venus and that all parts of Venus' surface reflect, this means that the planet's period of rotation is about 11 days, according to Kotelmikor and Shklovskiy. If Venus' axis of rotation is assumed to have an inclination in agreement with results derived by Kuiper, the Russian data indicates a period of rotation of close to nine days.

**Orbital Rendezvous for Apollo?** Orbital rendezvous techniques will get their first tryout by mid-'62, according to NASA administrator James E. Webb. The test will not involve an actual linking of vehicles but rather a close approach and fly-by.

This news indicates a change in NASA's approach to the problems of the propulsion system for a manned lunar landing mission, which previously had pointed to a non-stop trip. The switch probably reflects the opinion of the Golovin Large Launch Vehicle Planning Group, which has been studying the giant boosters that will be needed for the lunar Apollo flight and other heavyweight space missions. The projected Nova would involve clusters of eight Rocketdyne F-1s of 1,500,000 lb thrust each in the first stage or of 12 or more solid rockets with about 20,000,000 lb total thrust. The rendezvous technique would make it possible to use smaller booster, powered by 2-4 F-1s. Such boosters might be ready as much as two years sooner than a monster like Nova—but unfortunately the problems of orbital rendezvous are monstrous, too.

**Six-Legged Moon Vehicle** A working model of a lunar exploration vehicle that gets around by walking on six "legs" has been developed by Space General. In its full-size version, the robot would stand five feet high, but would fold into a 40×40×12-in. package for its trip to the moon. This foldability was one of the advantages of the walking system, which was also picked over rolling systems on the basis of efficiency, weight, size, environmental resistance, terrain capability, and speed. Size and weight are limited by the launch vehicle's capabilities, and high efficiency is required because of power limitations. The Space-General design would require only about one square yard of solar cells for operation. Only little speed is needed—the vehicle's approach to an obstacle should be slow enough to leave time for a TV picture of the obstacle to be transmitted to the operator on earth, for the operator to recognize the obstacle and react, and for his command signal to get back to the moon.

**Flight Line Van Linked to NBS** Standards lab on wheels was placed in operation by Lockheed California "to provide 100 per cent quality assurance for aircraft instruments being installed or checked on the flight line." A radio link in its 40-ft-long, 10-ton van connects the lab to the Bureau of Standards in Washington, D. C., to pick up calibrating signals. The van was used for the first time on the F-104 NATO flight line.

**B-70 Anti-Skid System** A fifth-wheel anti-skid system for control of the wheel brakes has been added to the landing gear of the B-70. NAA says the new unit—developed by Cleveland Pneumatic Industries—can stop the Mach 3 plane on any runway that can handle the B-52, and provides automatic protection against skids and blowouts.

The fifth wheel is considerably smaller than the main landing gear wheels. Its rotational speed and that of the main wheels are compared by computers to determine the amount of slippage between the brakeable wheels and the runway surface. Inputs covering wheel loading, brake torque, and speed give the computer the facts

→

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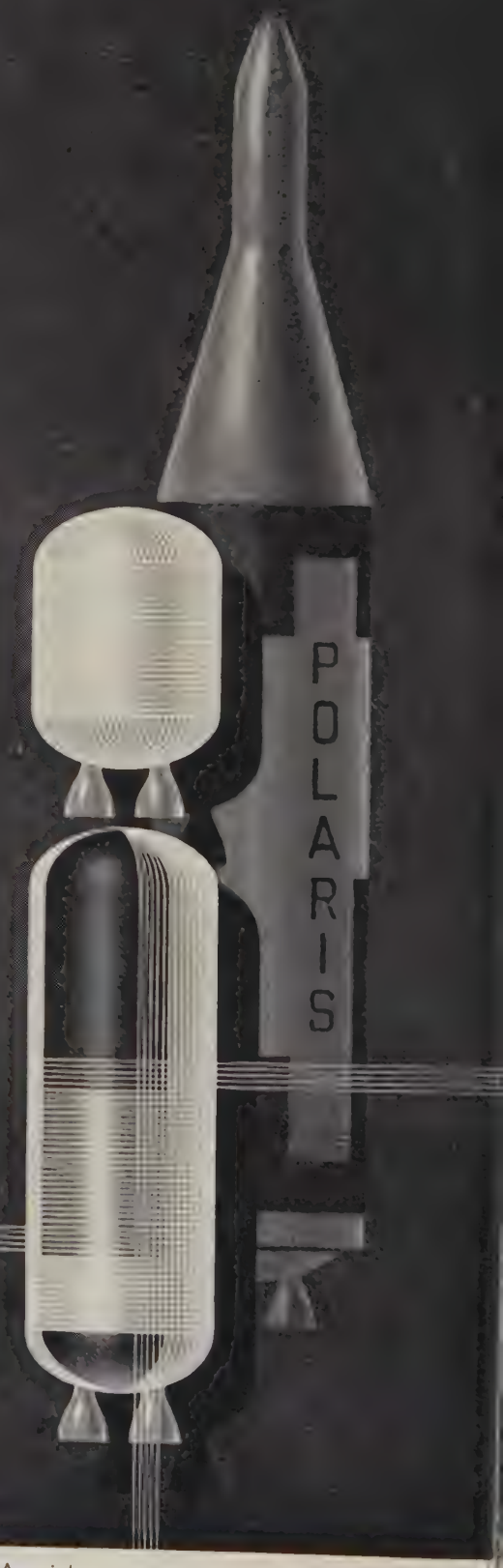


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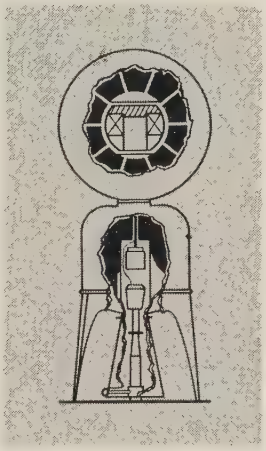
for determining the ground coefficient of friction. A comparison of the rate of change of slippage and the friction coefficient predicts the skid point, and brake pressure is automatically regulated to prevent skidding.

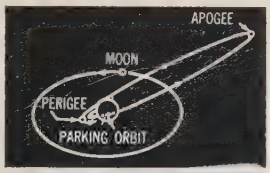
**Ranger Landing Capsule** Lunar landing capsule to be built by Aeronutronic for the Rangers RA-3, -4, and -5 is 25 in. in diameter and has a 12-in.-diameter survival sphere inside a thick outer balsa wood shell. This sphere floats in a liquid that helps distribute the structural loads of the lunar impact. The overall capsule weighs 300 lb and contains a seismometer to record moon quakes, temperature recorders, and other instruments. (See also *S/A, "Ranger: First U. S. Moon Impact Vehicle," Feb. '61, p. 45.*)

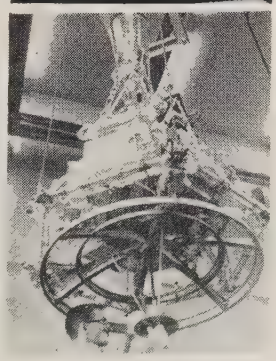
Once the capsule has detached itself 20-25 miles above the moon's surface, a solid retrorocket will slow it down. Made by Hercules Powder, the rocket weighs 195.9 lb and is dynamically balanced to minimize alignment errors when the capsule is spin-stabilized. The spin rocket system, developed by Aeronutronic, is installed in the cone of the retrorocket nozzle and will be jettisoned when the retrorocket ignites. Impact speed on moon's surface will be under 150 mph.



**Ranger Orbit Tried Again** Ranger 2 meanwhile was scheduled for launching late last month. It was to be injected into a highly elliptic trans-lunar orbit from a 115-mile parking orbit by restart of its Agena-B carrier's Bell engine. Ranger 1 on Aug. 23 failed to achieve this orbit—it remained in a low orbit.

Both satellites were designed to test systems and equipment for lunar and planetary missions as well as to carry out scientific experiments. They carried an attitude stabilization system based on sun and earth references, a high-gain aimable antenna, an advanced communication system, and instruments for eight experiments concerned with cosmic rays, magnetic fields, radiation, and dust particles in space.



Ranger 2 is slightly more than five feet in diameter at its base and 11 ft long. Its total weight is 675 lb. It has two solar cell panels, each about 10 ft square. A total of 8680 cells is expected to furnish a minimum of 155 W of energy. Because of uncertainty about the exact energy conversion efficiency of the cells, four specially calibrated cells were included to get data on cell performance in space.

**HP-115 Research Plane** The only new aircraft of technical interest shown at Farnborough this year was the Handley Page 115 research plane. A narrow delta with a span of 20 ft and a length of 45 ft, it is designed to explore low-speed aerodynamic and handling problems of the configuration, favored for a possible British supersonic transport. Its wings have a bi-convex section of moderate thickness, without any twist or camber. The leading edges, which came to a sharp point on the test plane, are made of fabric-covered plywood and can be changed.

**Red Test Shots** Six Russian vehicles were fired into a target area in the South Pacific in series of tests of what Tass described as a "new, more powerful multistage carrier rocket" designed to orbit "future satellite spaceships." The distance covered by four of the six shots was given as about 7500 miles. (No range was given for the other two shots.) All shots were claimed to have hit with high accuracy—in one case, within 0.62 miles of the target.

**VTOL To Cruise at 300 Knots** Tri-service VTOL transport developed by a team consisting of Hiller Aircraft, Ling-Temco-Vought, and Ryan Aeronautical will be powered by four GE T64-6 turboprop engines mounted on a tilting wing and have a cruising speed of 250-300 knots and a top speed at sea level of 400 knots. Its combat radius will be 200-300 nm, carrying 32 fully-equipped troops or equivalent weight. Auxiliary fuel tanks will give it a ferry range of 2600 nm. The cargo compartment, limited in size by the requirement that the plane operate from small, unprepared landing areas, is 30×7×7½ ft. The engines will drive a horizontally mounted tail-rotor through a gear train and shaft, as well as conventional 15-ft propellers. For takeoff and landing, the wing will be able to rotate through 100 deg, so that the plan can hover in a tail wind. Outboard sections of the full span double-slotted flaps will act as ailerons, and leading edge flaps outboard the engine nacelles will correct for prop slipstream up-flow during transition.

**West Ford Gets O.K.** President Kennedy's Science Advisory Committee gave the go-ahead to a tryout of Project West Ford, in spite of the international protest raised against the plan to sow a belt of fine copper needles around the earth to reflect radio waves. A special panel of the committee, headed by Dr. John W. Tukey, professor of mathematics at Princeton, reported that the test belt would not interfere with visible ultraviolet, or radio astronomy, and would not constitute a hazard to manned space flight.

The test belt is to consist of 75 lb of thread-like copper wires, to be discharged from a Midas satellite as it goes into polar orbit. They are expected to form a narrow belt around the earth at a 2300-mile altitude.

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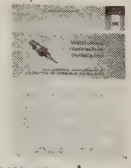

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# MEN BEHIND THE PROJECTS

*Briggs*

*Solar power system for satellite*

Air Force's Systems Command's Aeronautical Systems Division awarded a $50,000 contract to Westinghouse's Aerospace Electrical Department, Lima, Ohio, for a four-kilowatt solar photovoltaic power system to be used in a stationary equatorial communication satellite. The design includes a deployable array covered with photovoltaic converters, a solar orientation system for the array, and static control and conversion equipment to provide the needed quality of electric power for communication use.

"This type energy conversion system," says project engineer Robert Briggs, "is well suited for such satellites because: a non-diminishing supply of solar energy doesn't require the launching vehicle to carry the primary source for the electric power system; the static system offers the possibility of several years of continuous operation."

Briggs got a BSEE in '57 from Ohio Northern University. He was project engineer for Phase I study for Project SPUR.

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*Melchor—"Small R&D companies can compete"*

Hewlett-Packard has formed a new affiliated company to do solid state research and development, called HP Associates, Palo Alto, Calif. The new firm will do contract work for other companies and government agencies in the solid state field. Its major emphasis is on semiconductor devices, electro-luminescence, photoconductivity, and thermoelectricity as areas of immediate R&D work because of their importance to instrumentation.

"We feel that a small R&D company can compete and make valuable contributions in the specialized solid state devices market for instrumentation," HPA president Jack L. Melchor told SPACE/AERONAUTICS. "Aside from thermoelectrics, we are interested in the general problems of energy conversion in solids. This interest carries beyond devices suitable for instrumentation, centering more on contributions to scientific knowledge of energy conversion."

Dr. Melchor earned his BS and MS degrees in physics at University of N. Carolina, his Ph.D. at Notre Dame. In 1952 he worked part time with the Missile Division, Bendix, and in 1953 joined Sylvania Electronic Defense Lab, where he headed a study group on ferrites at microwave frequencies. In 1956 he co-founded Melabs, serving as its first president.

"Personally, I feel that the decade ahead will see tremendous strides in technological and scientific advances of solid state electronics and in energy conversion," Melchor believes. "In terms of contract work, we'd like to do materials work on II-VI and on III-V compounds; work on solid state relays, and in the associated logic systems; work on ultra, ultra high speed semiconductor devices. We are looking for top technical men in these areas."

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*Zisfein*

*Tunnel tests instead of flight tests*

A study of the feasibility of performing dynamic stability and loads testing in wind tunnels is being made by Giannini Controls Corp., Astromechanics Research Div., Berwyn, Pa. The project is jointly sponsored by the Flight Dynamics and Flight Controls Laboratories of Aeronautical Systems Command, Wright-Patterson Field, Ohio.

Chief investigator for the Air Force contract is Melvin B. Zisfein, manager of Astromechanics Research Division. A graduate of MIT in 1948 with BS and MS in aeronautical engineering, he started work at the Naval Aircraft Factory, where he remained until 1951. Subsequently, Zisfein held engineering positions at Bristol Engineering Corp., Lockheed Aircraft, Burbank, and Bell Aircraft, Buffalo.

"This study program," says Zisfein, "is expected to provide the first opportunity for a design team to detect experimentally a vehicle's critical flight conditions before actual flight testing. It will use maneuvering models of aerospace vehicles. Time and cost savings in flight testing operations should be considerable."

Dollar value of the Aeronautical Systems Command contract to Giannini Astromechanics Research Division is not revealed. However, the company said there will be eight engineers on the project.

---

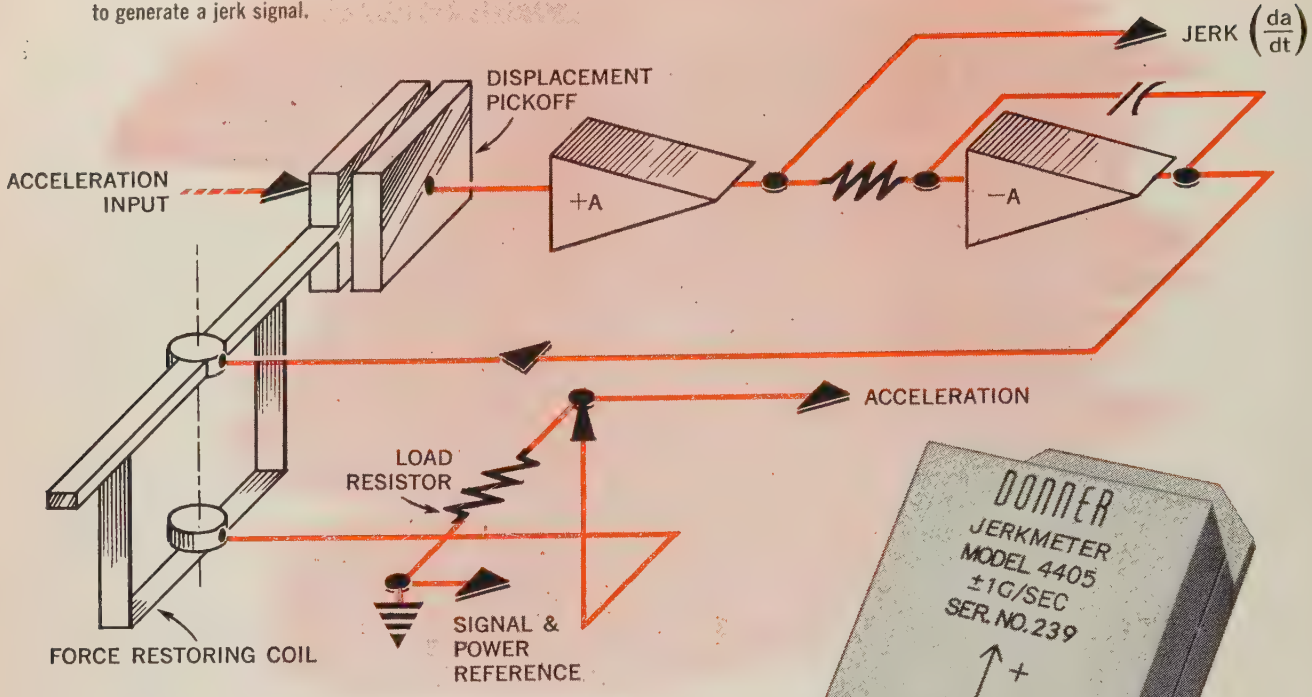
*Van Winkle*

*"New concepts in booster handling needed"*

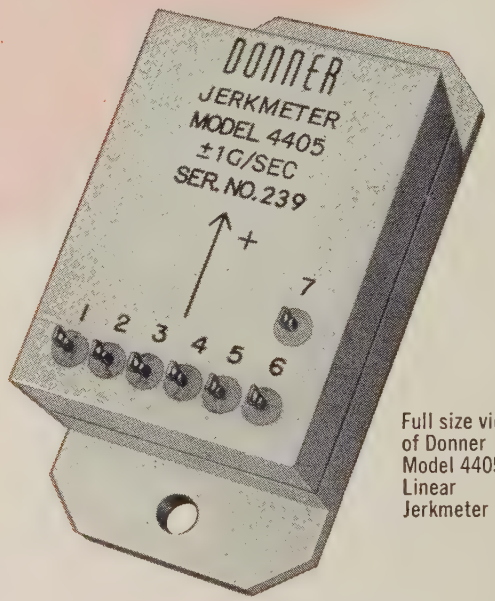
"The mammoth size of handling equipment for movement and assembly of these super boosters will require new concepts in handling," says George Van Winkle, manager of Boeing's solid booster studies for NASA. Some of the boosters the Seattle, Washington, firm's Aerospace Division is studying have first stage thrusts of 8-11 million pounds, he points out.

"Our studies include single unitized designs, clusters of smaller unitized motors, and clusters of segmented motors," he explained. "One of the first-phase objectives is to find which one or combination offers the most advantages." Fur-

● Functional diagram of Donner Linear Jerkmeter. This unique instrument operates as a subminiature servo-system of the force-balance type which is responsive to jerk along the sensitivity axis of the linear unit and about the sensitive axis of the angular unit. Basically, the system consists of a transistorized accelerometer with an integrator inserted into the servo-loop to generate a jerk signal.




# HOW TO MEASURE $\frac{da}{dt}$




Full size view of Donner Model 4405 Linear Jerkmeter

## *New Donner precision Jerkmeters measure linear and angular jerk to ±0.5% or better.*

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Typically, a jerkmeter installed in a jet aircraft will provide an instantaneous output proportional to the rate of change of g's. This signal can be used to predict impending disaster conditions.

Other applications include use wherever constant acceleration is required. Here, the Donner jerkmeter provides a "velocity-damping" term. The jerkmeter also provides a third order term for stabilizing displacement devices. It can also be used as an inertial indicator of first motion.

KEY SPECIFICATIONS for Model 4405 Linear Jerkmeter

RANGES
Acceleration: ±1 g full range to ±30 g full range
Jerk: ±0.5 g/sec full range to ±20 g/sec full range

OUTPUT FULL SCALE
Accelerometer: ±7.5 v dc
Jerk: ±7.5 v dc

RESOLUTION
0.1% full scale or better

LINEARITY
0.1% full scale or better

HYSTERESIS
Less than 0.1%

POWER
+15 v dc at 10 ma and −15v dc at 10 ma

SIZE
3" long, 1½" wide, 1⅝" high

WEIGHT
7.5 ounces

**WANT MORE INFORMATION?** *The new Donner Jerkmeter is another product from a firm specializing in the manufacture of accurate fixed and general purpose analog systems designed to analyze, measure, and control inputs interlocking time, acceleration, jerk, velocity, and other dynamic inputs. Complete technical information can be obtained by calling your nearby Donner engineering sales representative or writing Dept. 103.*

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ther design work will be done on such power plants in the second phase to provide an improved basis for determining overall support system requirements, program costs and timing, and developmental requirements. The study efforts will be concluded early next year, and cost about $100,000.

The contract award stems from NASA's lunar flight program. Clusters of either solid or liquid propellant boosters are being considered for various phases of the space trip.

Project engineer Van Winkle believes the major items requiring development emphasis, in addition to moving and handling, include: setting up development testing concepts that are both economically practical and adequate to insure operational reliability; control system development; reliable and simultaneous ignition of motor clusters; malfunction detection and escape of crews in manned vehicles; effects of high noise levels; development of structure for motor clusters.

Boeing, a pioneer in Pert (*p*rogram *e*valuation and *r*eview *t*echnique), has adopted an abbreviated version to make the study. Van Winkle said they use Pert to "define each task in the various technical areas and to tell us whether these activities should be carried out in parallel or in series to meet schedule milestones."

The contract pays for the efforts of about nine research engineers. If the program expands into a hardware-building project, Boeing might need personnel with special solid rocket experience.

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*Atkins*

***Feed systems for ion engines***

Cesium propellant feed systems for spacecraft engines are being studied under NASA contract at National Research Corp., Research Div., Cambridge, Mass. Heading the project is Dr. J. H. Atkins, who won his doctorate from Rensselaer Polytech.

"Special problems involved in such feed systems," he told us, "are based on the fact that cesium is the most reactive metal known in liquid or vapor phase, and probably is the most corrosive metal also." NRC will study the properties of this fuel, recommend materials for design of the fuel injection system, and evaluate feed systems which could handle cesium at varying rates. The company has a wide experience in handling alkali metals, as well as in ultra high vacuum technology and research in the behavior of materials in space conditions. It has the basic patent for design of a space simulation system large enough to take prototype rocket engines for firing.

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*Coppa*

***Buckling studies of shell structures***

Scientists of General Electric's Missile & Space Vehicle Dept., Philadelphia, Pa., are buckling down to the study of buckling metal cones and cylinders. The project will take a year, and is sponsored by the USAF Aeronautical Systems Division, which awarded a $96,200 contract for the study.

The scientists have found that metal cylinders absorb large amounts of energy when they buckle on impact. "Several practical applications are expected to result from this program," says Anthony P. Coppa, research engineer in charge of the work. These include "the use of pressurized shell structures as decelerating devices for lunar landings, and methods of forming integrally stiffened shell structures by impact. Knowledge gained about the forces transmitted through shell structures during impact against various media will be applied to protecting missile and space vehicle payloads against impact forces," Coppa told SPACE/AERONAUTICS. Some of the important questions to be answered center about the mechanism by which instability is begun in a shell under axial impact, he added. Specifically, it must be determined whether instability can begin on the first passage of the stress wave produced on impact.

Coppa got his BME at Villanova, and MS in engineering mechanics at Univ. of Pennsylvania. He joined GE after working with Westinghouse.

---

*Zerbe*

***Testing for Saturn's instrumentation***

Effects and problems of space flight are being studied by Ling-Temco-Vought, Inc., under NASA contract. K. L. Zerbe, chief of Test Laboratories for LTV Electronics Division, Dallas 22, Texas, said his group will use the facilities of the company's Garland, Texas, environmental lab to simulate conditions a Saturn space vehicle would meet.

"Our group will test the effects of space flight environment on Saturn instrumentation," Zerbe says. NASA will supply the equipment to be studied. Effects of such simulated conditions as shock, acceleration, temperature, altitude, humidity, vibration, radio interference and salt spray will be studied during the six-month program. Zerbe did not explain why the effects of salt spray would be studied.

Zerbe, who got his BS in electrical engineering at Southern Methodist University in '54, worked at General Electric as a design engineer. He joined Temco in '55. Assigned to the Environmental Labs in '56, Zerbe has guided a program for determination and acquisition of about $750 million worth of test equipment.

## Rx for thirsty jets

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# CALENDAR

| NOVEMBER | | | | | | |
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| JANUARY | | | | | | |
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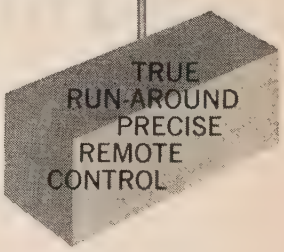
| **Nov. 6-8** | Special Technical Conference on Non-Linear Magnetics, IRE, Statler-Hilton Hotel, Los Angeles, Calif. |
| **Nov. 6-9** | 1961 Conference and Atom Fair, Atomic Industrial Forum and American Nuclear Society, Conrad Hilton Hotel, Chicago, Ill. |
| **Nov. 9-10** | 11th National Conference, Aircraft and Missiles Division of American Society for Quality Control, Ambassador Hotel, Los Angeles, Calif. |
| **Nov. 14** | Electronic Systems Reliability Symposium, Kansas City, Missouri |
| **Nov. 14-15** | SAMPE Ceramic Materials Symposium, Biltmore Hotel, Dayton, Ohio |
| **Nov. 14-16** | Second International Conference on the Exploding Wire Phenomenon, Boston, Mass. |
| **Nov. 15-17** | 19th Annual Aerospace Electrical Society, Pan Pacific Auditorium, Los Angeles, Calif. |
| **Nov. 19-24** | Medical Biological Problems in Space Flight Conference, Nassau, Bahamas |
| **Nov. 30-Dec. 1** | 12th National Conference, Institute of Radio Engineers' Professional Group on Vehicular Communications, Radison Hotel, Minneapolis, Minn. |
| **Dec. 4-5** | Conference on Beryllium Metallurgy, New York University, College of Engineering, New York, New York |
| **Dec. 5** | 2nd Annual Seminar on Reliability in Space Vehicles, Rodger Yound Auditorium, Los Angeles, Calif. |
| **Dec. 12-14** | 1961 Eastern Joint Computer Conference, Sheraton-Park Hotel, Washington, D. C. |
| **Jan. 23-26** | Solid Propellant Rocket Conference, Baylor University, Waco, Texas. |


PACIFIC Packaged CABLE CONTROL SYSTEMS




To meet the exacting requirements of controls in today's high performance aircraft and engines—Pacific Scientific has developed "packaged cable control systems."

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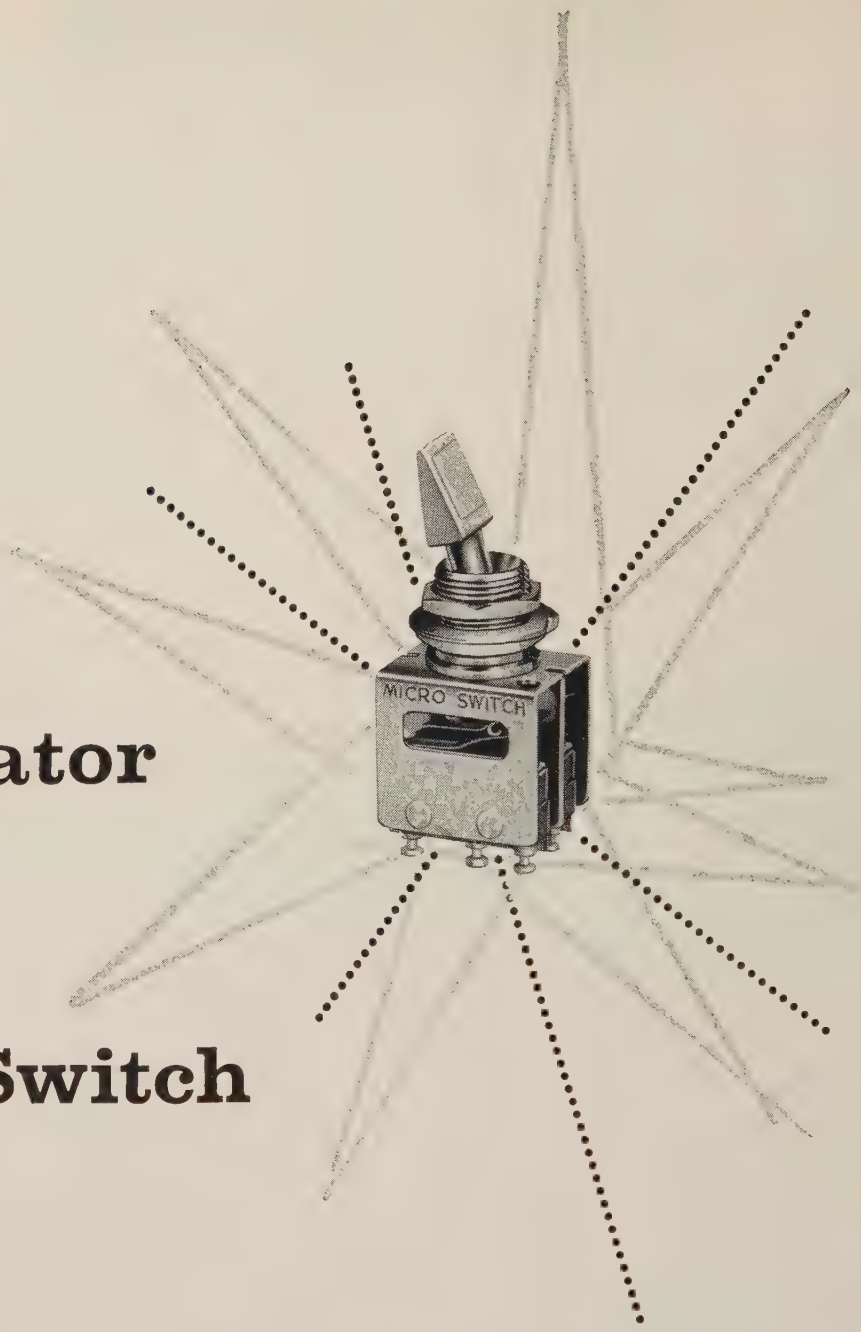
# Versatile Tab-Indicator Toggle Switch



**"400" SERIES TOGGLE SWITCHES**
Five models available, including 2-position and 3-position types. All are rated at 5 amperes, 250 vac.

The new "400" Series Toggle Switch from MICRO SWITCH has a paddle-shaped tab which can be numbered or color-coded as an indicator. The standard model has a natural metallic finish which will maintain a fresh appearance through long and constant use. The anodized aluminum tab is also available in black or in colors.

The basic switches used are precision snap-action, long-life units, requiring a minimum of space. They conform to specifications for MIL-S-6743, with two isolated single-pole double-throw circuits. Turret terminals make wiring easy, and contact enclosures are dust-tight.

Five models are presently available in the "400" Series, including both momentary and maintained contact types. Write for Data Sheet No. 174 describing these new tab-indicator toggle switches.

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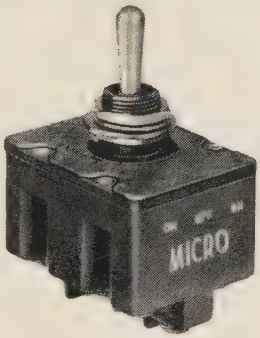
MICRO SWITCH Precision Switches

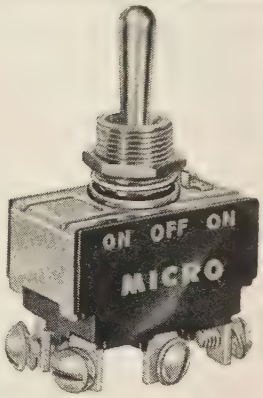
"1TL" Series



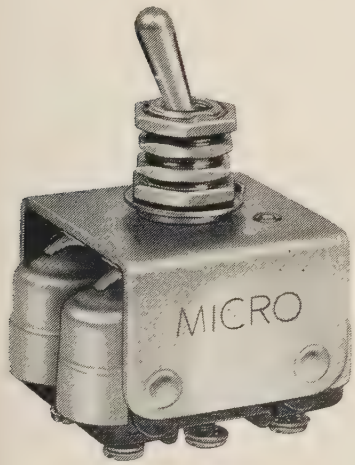

"4TL" Series

"1TL" Pull-to-Unlock

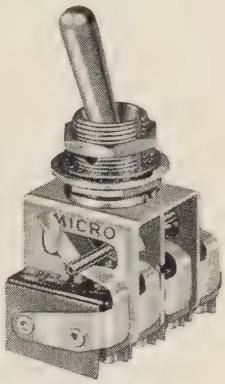
1-Pole "TS"



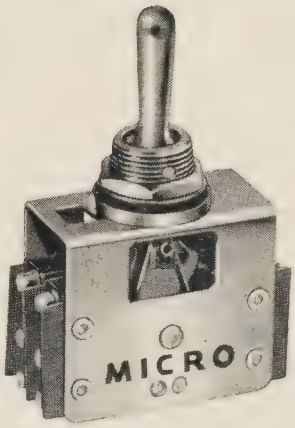

2-Pole
Sealed "TS"



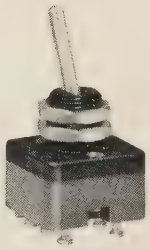

Hermetically Sealed
Assembly




4-Switch Assembly




"Electrical Memory"
Assembly



Subminiature "TM"

## Precision Toggle Control Can Be Customized

MICRO SWITCH manufactures hundreds of different toggle switches and toggle switch assemblies. In this complete line you can find the exact characteristics and contact arrangements you need.

**"TL" Series** Silicone sealer between cover and case seals against dust or moisture. These switches are approved under MIL-S-3950A, operate in a temperature range of —85°F to +250°F. Available in 1, 2 and 4-pole models with integral terminals.

**"TS" Series** The toggle lever is sealed against dust and moisture. "TS" toggles meet specifications for MIL-S-3950A. Special plastic barrier plus extra distance between terminals. A keyed bushing prevents rotation. Wide choice of contact arrangements includes 1, 2, 3 and 4-pole types.

**Subminiature "TM"** Weighs only 4½ grams, measures only ½" x ½" at the base. Double-pole double-throw with wide temperature range and low circuit resistance.

**"AT" Series Toggle Assemblies** MICRO SWITCH offers toggle switch assemblies of up to 16 basic switches. Hermetically sealed types are also available.

There is a MICRO SWITCH branch office near you and prompt engineering help on the selection of toggle switches is available by simply checking the Yellow Pages. Be sure you get MICRO SWITCH precision and reliability.

**WRITE FOR NEWLY REVISED CATALOG 73 ON TOGGLE SWITCHES**

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No. 29 on Reader Service Card

SURVEY

by **James Holahan,** Electronics Editor

# What have we got to counter

WHEN THE ICBM first appeared on the scene, the problem of defending ourselves against it seemed relatively simple to define, at least, though exceedingly difficult to solve. By now, not even the problem is simple any more. Enough new variables and unknowns have been added by advanced designs to leave us quite uncertain about the precise parameters of the anti-ICBM problem.

The threat is no longer the "simple" ICBM. By now, we must assume, the enemy can launch many ballistic missiles—IRBMs as well as ICBMs—at us at one time, along with screens of sophisticated decoys. And these missiles may be launched from any of many land bases, from the air, from ships, from submarines under the sea. Even space-launched ICBMs may be soon added to the threat. The missiles themselves are sophisticated, too—the techniques are already available for changing the speed and course of their warheads in flight.

Nor is this all. If the anti-ICBM weapons we are now working on will stop only the ICBMs the enemy has today, they are useless—they must stop the more advanced ICBMs the enemy will have tomorrow, when our counterweapons are operational. As the enemy's future capabilities are difficult and some time impossible to assess, the design of our counterweapons must leave room for drastic changes to be made as we learn more about the enemy's progress.

Just as formidable as the technical problem is the economic one. Literally nothing in ICBM defense is cheap. A decision to go ahead with the hardware development on an anti-ICBM system would commit us to an expenditure of almost a billion dollars. Production of such a system would require a minimum starting investment of about eight billion dollars. At these staggering prices, we can't afford many wrong decisions or many changes of horses in midstream.

Our current efforts are concentrated on the Nike-Zeus and Defender programs. A much smaller role is being played by the Saint (*sat*ellite *int*ercept) program (an outgrowth of Defender). Saint, under development at Lockheed for USAF, at this point is not really an anti-missile system, but rather a system for satellite inspection in orbit. However, it might eventually provide the basis for a satellite interceptor-destroyer.

## Nike-Zeus is our only hardware

Only the Army's Zeus exists in hardware form—an operational prototype is being readied for full-scale tests against Atlas ICBMs. For Saint, potentially a weapon that could be used against satellite launched ICBMs, experimental hardware is being built.

Defender is not a system program in the usual sense but a series of research, subsystem-developments, conceptual-model studies, all concerned with the fundamental physical problems of ICBM defense. It is being run by the Advanced Research Projects Agency (ARPA), which reports directly to the Secretary of Defense. Its most promising development so far is Arpat (ARPA plus *t*erminal), a terminal-phase intercept system for which a feasibility test model is being built for evaluation.

Though Zeus is the only anti-ICBM weapon we have that is anywhere near operational status, there is considerable doubt that it will ever be produced. Not even if it proves that it can do the job for which it was

IN BRIEF

*The systems we are working on to defend ourselves against long-range ballistic missiles vary according to the phase of the attacking vehicle's flight during which the intercept is to be made. For the boost and terminal phases, detectability is excellent but the time for intercept is extremely short. For the midcourse phase, this time is longer, but detectability at present is virtually nil.*

*Zeus, a terminal-phase design, is our only system nearly ready for use. For Arpat, another terminal-phase system, a feasibility model is being built, while Helmet, a third terminal-phase system, is still in the conceptual stage. Bambi, a launch-phase concept, is under study. Saint, which is being designed as a rendezvous system for satellite inspection, also has possibilities as a weapon to counter space-launched ICBMs.*

# the ICBM threat?

designed will its future be assured. It may already be obsolete in view of the technical advances made by the ICBM offense since it was started a little less than four years ago.

Many of the decision-makers in the Defense Department argue that Zeus is not flexible enough to be modified to meet even the enemy's estimated current offensive capability. They claim that it cannot be brought to the point where it will not be fooled by decoys, saturated by large-scale attacks, or overwhelmed by satellite-launched ICBMs.

Right now, Zeus is costing us a mililon dollars a day to develop. To produce it would cost a billion a year. To produce enough Zeus systems to defend about one-third of the U. S. population would cost some $14 billion dollars. If Zeus is actually ordered into production, there is a good chance that it will become the most expensive military item in U. S. history.

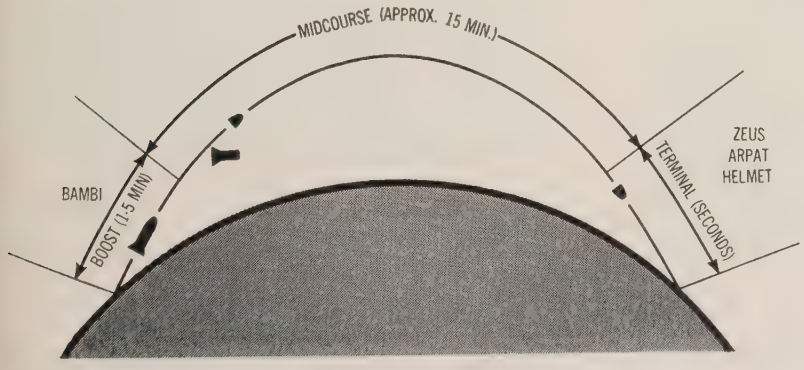
So far some 900 million has been spent on Zeus R&D, part of it for highly reliable electronic components (including silicon mesa transistors and thin-film resistors) being made by Western Electric on special production lines. By the time the Zeus prototype system is completed and tested, it is expected to have cost $1.75 billion.

The Eisenhower administration was openly cool to the idea of Zeus production, and the situation does not appear to have changed under Kennedy, who also has withheld the production O.K. eagerly sought by the Army. However, the Soviets' resumption of nuclear tests and the growing rumors that they may have an anti-ICBM weapon have put strong pressures on the administration to start at least token production of Zeus.

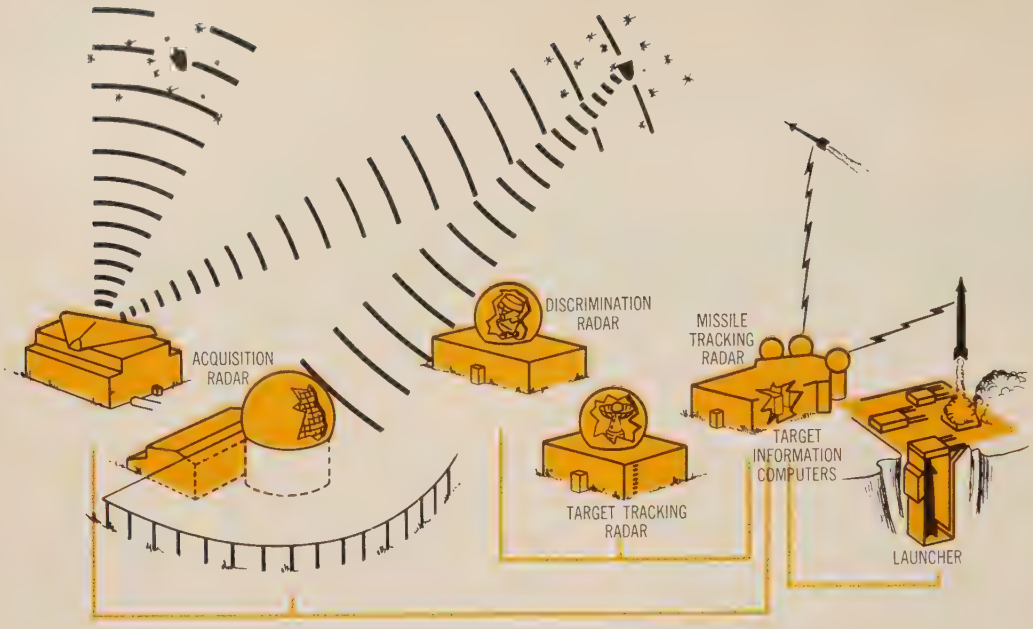
**The Reds' Boast**

"Our long-range ballistic missiles can deliver nuclear warheads to any point of the world irrespective of the time of day or year or of meteorological conditions. They insure the possibility of delivering powerful blows simultaneously on a considerable number of targets while remaining invulnerable . . . to modern means of counteraction."

Marshal Kirill S. Moskalenko
Chief, Soviet Rocket Command




**CURRENT** U. S. anti-ICBM projects cover only two of the three basic phases of ICBM flight. ARPA's work on midcourse-phase defense is restricted to attempts to find secondary effects of a warhead's passage through space that might be used for detection. Bambi, Arpat, and Helmet are all ARPA projects, while Zeus is an Army design. Work is also being done on Saint, which conceivably might become a counter to satellite-launched ICBMs.




**MAJOR** elements of the Nike-Zeus anti-ICBM system. The receiver and transmitter of the acquisition radar use separate antennas.

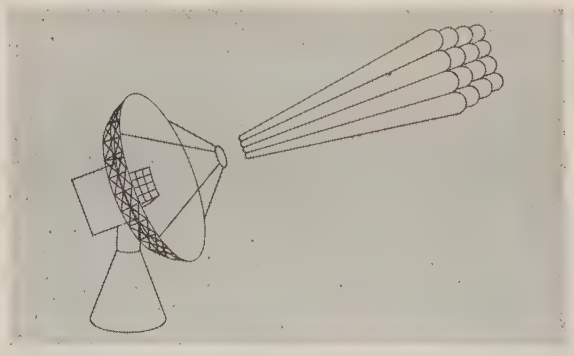
## Defender and Radar

One of the main areas of Defender research is advanced radar. Several programs are underway, some of which have already led to considerable advances in the state of the radar art.

### Pincushion

Developed by Rome Air Development Center and Raytheon with the aim of concentrating high power in a small beam, this radar uses a large dish and radiates a stack of beams, each about 0.1 deg wide. Each beam could have a different frequency, to give a very-high-frequency radar the low-frequency system's advantage of a wide aperture. Pincushion can put a great deal of power on a target and at the same time get high angular and velocity resolution. Raytheon is completing a Pincushion radar for ARPA. It will use cassegrainian optics, and the transmitter will be mounted on the antenna pedestal and will rotate with it.

Originally ARPA intended to use Pincushion on Roi Namur, an island near Kwajalein, as part of Project Press, an experimental study of the electromagnetic signature of ballistic missiles. However, ARPA concluded that it would cost about $4-5 million to install Pincushion on Roi Namur and about $2-2.5 million to operate it there and dropped the idea. Though it has no immediate use for Pincushion, it believes the radar is worth having on the shelf. Many of the signal processing techniques and the pedestal drives and feeds developed for Pincushion are directly applicable to the Arpat radar, also a Raytheon project. In fact, ARPA estimates that the use of Pincushion designs in the Arpat system will save at least $0.5 million.



### Missile Tracking Radar

In September 1960, ARPA got its first good radar data on an actual ICBM warhead in flight using the two FPQ-4 radars of the ocean-going American Mariner tracking ship

It's already being argued that, even if Zeus proves only marginally effective, it should be built on the grounds that a marginal defense now is better than a foolproof one that's 5-10 years away. Of course, most of Zeus' advocates profess to have no doubts about the system's effectiveness. They also deny that it is not flexible enough—they claim that it could be expanded to cope with more sophisticated ICBM attacks by mating it with the techniques that come out of the Arpat program. While the final decision on Zeus will depend largely on the outcome of the full-scale tests set for early next year, all these pressures undoubtedly lower the passing grade.

## Zeus to be launched against Atlases

For the all-important tests, a facility is being completed on Kwajlein Island in the Pacific from which Zeus will be launched against Atlas ICBMs coming in from Vandenberg AFB, Calif. The Defense Department plans to make the tests as realistic as possible, using full complements of electronic countermeasures and decoys.

The last unit of the system being installed on Kwajlein is the Zeus discrimination radar. Designed by Bell Labs, this radar is believed to be the most sensitive and conceptually most advanced element of the Zeus system. In the absence of any official information on this design, all that can be assumed is that it is quite likely to be a high-power, high resolution system that depends to a considerable extent on a priori data on the target's characteristics. It may also have variable operating parameters to protect it against countermeasures.

## Decoy discrimination is at issue

Perhaps the key question that DOD hopes the tests will answer is, How well can Zeus discriminate against decoys? The scientists working on Defender told SPACE/AERONAUTICS that they believe Zeus might be able to discriminate between warhead and the debris (booster, casing, etc.) following it but not between a warhead and a sophisticated decoy. The Army's answer to such criticism is that it has studied decoys of every conceivable sort and found that the only thing that behaves just like a warhead is another warhead. It confidently claims that Zeus in its present form can destroy a warhead both in the atmosphere and in space, and that it can be extended to a range of 1200 miles.

When the Army started Zeus, it wanted to design a weapon to stop ICBMs. When DOD and ARPA started De-

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The FPQ-4 is a modified version of RCA's widely used FPS-16 instrumentation radar. It operates in C-band, puts out a 0.8-deg beam, uses monopulse tracking, and has a range of 100-500 miles. One of the FPQ-4s on the American Mariner uses conical scanning to acquire the target before reverting to monopulse for tracking.

The test warheads, which came from Atlas ICBMs, carried transponders to facilitate acquisition and tracking. The beacon frequency was slightly displaced from the radar frequency so that beacon-and-skin-tracking return might be distinguished on the display.

### Ordir

An omnidirectional, multi-static long-base-line radar using coherent-integration signal processing, this system was originally developed by Columbia U.* ARPA is interested in Ordir as a research technique for the study of signal processing and multistatic systems. It believes that the concepts of the system are excellent but that they cannot be turned into hardware until state-of-the-art improvements have been made in certain key components (e.g. linear filters).

The Air Force is also interested in the Ordir principle and has supported most of Columbia's research in this area. It commissioned ITT to build a hardware model of which was called Lobar (Long-Baseline Radar). Although Lobar reportedly workked quite well, it was never ordered into production. It is believed that the Achilles' heel of the system was that a synchronizing signal has to be sent to each station. This raises a communications problem and creates a link vulnerable to electronic countermeasures.

* Coherent-integration signal processing is used to detect weak pulses against a background of random noise and involves the integration of the received pulses before envelope detection. When the phasing of successive pulses has been corrected for target motion, the signal power is increased by N times the noise power. (The signal voltages add linearly, while the noise voltages add in an RMS manner.)

### Esar

Developed by Bendix Radio for ARPA, ESAR (electronic scanning array radar) represents the first workable model of a phased-array radar. Five stories high and containing some 9000 elements, it is an important radar milestone in electronic scanning, undoubtedly will play a major role in future long-range systems.

### Over-the-Horizon Radar

ARPA is the coordinator of fmilitary OH radar programs. It is studying ionospheric-bounce phenomena as means of OH detection and claims that it is on the verge of an important discovery in this area. Its immediate goal is to write the radar equation for OH systems.

Known OH radars operate in the HF band. Their advantage, of course, is that they overcome the line-of-sight limitations of conventional radars and theoretically give a four- or fivefold increase in the single-hop earth-to-earth range. They are limited by our inability to forecast atmospheric anomalies and to calculate their effects on the radar beam.

### High-Power Radar

ARPA has programs underway at Cornell Aeronautical Lab and at Lincoln Labs. CAL has developed a system that can put out 50 Mw of peak power. ARPA also has a contract with Varian Associates for the highest-powered radar tube yet developed in an S-band klystron. ARPA says this tube is the best that can be had at "last year's state of the art."

### Zeus 1961-62

The Army recently awarded a $171,821,000 contract to Western Electric that will extend the Zeus development and test program another 12 months. Sharing in the contract will be Avco Research Labs ($2 million), Continental Can ($1.2 million), Continental Electronics ($3.05 million), Cornell Aeronautical Labs ($1.65 million), Douglas Aircraft ($57.7 million), Goodyear Aircraft ($3.05 million), New Mexico State U. ($0.7 million), Remington Rand Univac ($6.78 million), and Sperry Rand ($5.375 million).

fender in 1958, they were at once more modest and more ambitious. They set out on a broad series of exploratory studies of defense system concepts and techniques and of the physics of ballistic missiles, data processing, discrimination, interception, kill mechanism, missile range measurements, infrared, and radar. The goal of this entire effort (which includes the free exchange of research data with the Zeus designers) is not to come up with any particular weapon but primarily to gain the basic knowledge that will lead to anti-ICBM systems that are technically, operationally, and economically feasible and secondarily to find the means of evaluating these systems. Since the answers to the most acute problems of ICBM defense appear to lie in the areas of electro-physics and electronics, these are the areas in which the bulk of the Defender work is being done.

## ARPA contracts are let indirectly

ARPA's Defender contracts are let through the three military services—normally through the service most directly concerned with the area covered by a given contract. In its technical and economic evaluation of system concepts, ARPA calls on the help of consulting groups from universities and non-profit research organizations. If after this evaluation a system appears feasible, a cheap, intermediate hardware feasibility model may be ordered for further evaluation. In view of the enormous cost of the final system, ARPA considers such a model "cheap" even if it runs into a few million dollars. The models of Arpat and Saint that are now being built both are the result of ARPA concept evaluations.

Defender got $125 million in last year's budget and $104 million in this year's. Unlike many defense projects, it is "idea-limited" rather than "money-limited," ARPA believes.

In ARPA's view, the anti-ICBM is divided by the three phases of ballistic missile flight—boost, midcourse, and terminal.

During the boost phase, an ICBM is vulnerable because it emits a terrific amount of radiation but is protected by its speed—before burnout, the counter-weapon designer has only 1-5 minutes to detect, track, and destroy. He also has the problem of where to base his observation equipment—the enemy's launch pads may be thousands of miles from his frontier. This appears to limit the defense to satellite-borne interceptors (probably equipped with IR or perhaps with a special miniature radar).

Through the Air Force ARPA has let three contracts on boost-phase intercept: to Convair for studies of techniques investigation and a token systems analysis and to Hughes Aircraft and Space Technology Labs for studies of techniques. These contracts are part of the Bambi (*b*allistic *a*nti-*m*issile *b*oost *i*ntercept) program—which in turn, ARPA stresses, is a part of Defender, even though this fact is not mentioned too often).

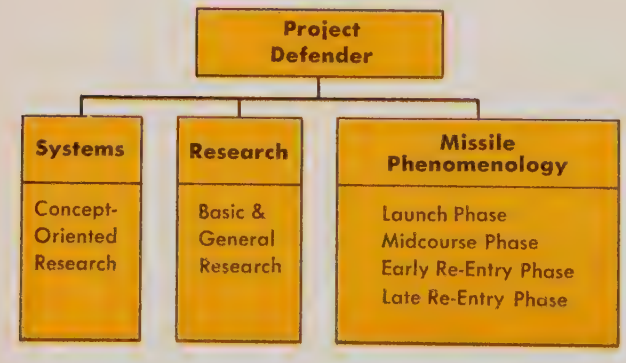
## Almost no radiation in midcourse

In the midcourse phase, an ICBM gives off virtually no radiation, since there is little or no atmosphere with which it can react. On the other hand, this is the longest phase—it lasts about 15 minutes. ARPA is trying to find out whether there are secondary effects of a warhead's passage through space that might be used for detection. (Before that, in its only other effort devoted to the midcourse phase, it had considered the possibility of sending up a vehicle to spot an attacking ICBM, but discovered that this defense would take about three times the energy of the attack. Since cost is more or less directly proportional to the energy expenditure, the idea was abandoned as a losing proposition.)

In the terminal phase, the re-entering warhead is traveling at about 23,000 fps (15,700 mph). The re-entry effects start at about 500,000 ft altitude. The defense has the advantage of being able to use large, ground-based radars and the disadvantage of critically short time—on the order of seconds—in which to take action.

ARPA has done some of its most fruitful work on terminal phase counterweapons. In September 1960, it made its first radar track of a re-entering ICBM warhead, using an FPQ-4 radar. Early this year, it approved the conceptual Arpat system for hardware evaluation. Designed primarily to cope with simultaneous attacks by several ICBMs, Arpat relies on a ground detection, tracking, and computation complex, just as does Zeus. However, instead of launching a single anti-missile at a time, Arpat sends up a mother vehicle carrying perhaps several dozen anti-missiles. Each of these spherical or ellipsoid "darts" probably weighs less than 50 lb. and has built-in homing guidance (possible infrared, optical or ultraviolet) and self-contained propulsion for maneuvering after launch.

When Arpat has detected attacking warheads, the carrier is launched 5-25 miles up into an area through which warheads are expected to pass. Once within range,




**IN DEFENDER,** ARPA is taking a three-pronged approach to the problem of collecting basic information on ICBM defense. Most of its work to date has been done on missile phenomenology, the least theoretical of its efforts.

**ACQUISITION** radar of the Nike-Zeus installation on Kwajalein in the Pacific. Made of plastic foam, the receiver antenna of this radar (bottom) is a large Luneberg lens with several independent receiver horns.

the carrier fires retro-rockets to halt its flight momentarily while it launches its darts, which have a range of several miles.

The Arpat concept was developed by the Institute for Defense Analysis, assisted by a number of other research groups. Working through the Army Rocket Guided Missile Agency (ARGMA), ARPA has placed orders with IBM for the ground computers, with Raytheon for the acquisition and discrimination radar, with Boeing for the carrier vehicle, and with Hughes for the darts for the experimental system.

## Helmet is still in early study stage

ARPA is also considering Helmet, a more radical terminal-intercept system that has not yet progressed beyond the stage of early study within government labs. The basic idea behind Helmet is to forget about discrimination and destroy everything that's coming at you—warhead, debris, and decoys. Theoretically, ARPA says, this idea has been proved feasible, but the means to carry it out are lacking so far and will be provided only by advances in the state of the art of low cost boosters and non-nuclear kill mechanisms.

## Glipar not to be repeated, ARPA says

Even more radical was Glipar (*g*uidelines *i*dentification *p*rogram for *a*nti-missile *r*esearch), a program under which ARPA tried to consider any hypothesis of ICBM defence proposed to it, no matter how exotic. So long as a hypothesis could not be disproved, ARPA was willing to study its feasibility.

ARPA got a lot of hypotheses that, though exotic in the extreme, indeed could not be disproved, but it found that they couldn't be proved, either. And that was the end of Glipar, ARPA says. It will not run anything like it again.

**by Carl R. Liebermann,** Weight Staff, Integral Engineering, The Martin Co.*

# Keeping hydrostatic tests from adding booster weight

A WEIGHT PENALTY of 1-5 tons is no small matter by any standard. Yet that's just what might hit the next generation of liquid boosters if present methods of hydrostatic testing are still used.

The weight of some of today's boosters already has been increased by hydrostatic-test weight penalties, but only by small amounts and usually only in the upper domes. In the recent past, axial, bending, and sheer loads—or even minimum gage restrictions—have determined the thickness of booster tank walls, requiring weights greater than those needed for hydrostatic test.

The next, third generation of boosters, however, will have tank diameters much larger than the present maximum of about 10 ft. Probably diameters of 20-30 ft will be used. Pressure vessels that have large diameters and moderate design pressures also inherently are able to support high axial and bending loads. So far as these loads are concerned, the designers of future big boosters almost literally won't have to worry about minimum gage. In that situation, hydrostatic test pressure loads may well lead to tank wall thicknesses greater than those required by other criteria.

In such tests, it is rarely possible to simulate the acceleration to which the tank contents are subjected during flight. In duplicating the flight pressures at the base or top of the tank, it therefore becomes necessary at times to apply "non-optimum" test pressures that exceed the maximum flight pressures.

*Figure 1* shows that a difference ($\Delta p$) exists between test and in-flight pressures. If we separate the tank into barrel and upper and lower dome sections, we therefore can write:

$$N_f = 1 + \Delta p_{avg\ test}/\Delta p_{avg\ theory}.$$

* The Martin Co., Baltimore 3, Md. This is a condensation of a paper, "Hydrostatic Test Weight Penalty in Big Boosters," given at the Society of Aeronautical Weight Engineers' 20th National Conference in Akron, Ohio, last month. The author wishes to acknowledge the contributions of R. W. Lanzkron, M. F. Taylor, W. H Ahl, Jr., and W. Van Arnam.

IN BRIEF

*Tank walls made thicker than they would have to be otherwise merely to withstand the pressures of hydrostatic testing are a definite possibility for future big liquid boosters. Here is an analysis of this potentially critical weight penalty, showing the parameters that determine it, its order of magnitude, and its effect in terms of payload weight. In particular, the important relationship between the tank diameter and this weight penalty is made clear.*

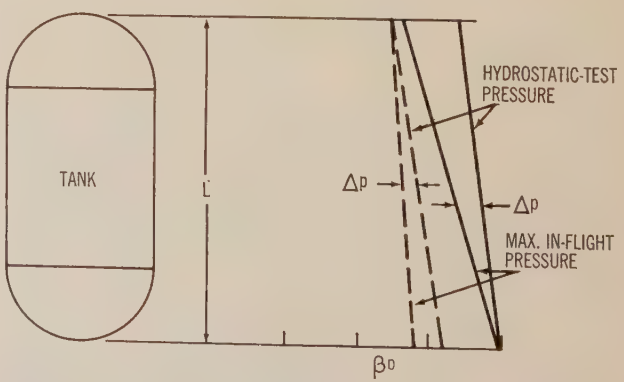



**FIGURE 1:** Booster tank pressure gradients for liquid propellants much denser than the test liquid (solid curves) and much less dense than the test liquid (dashed curves).

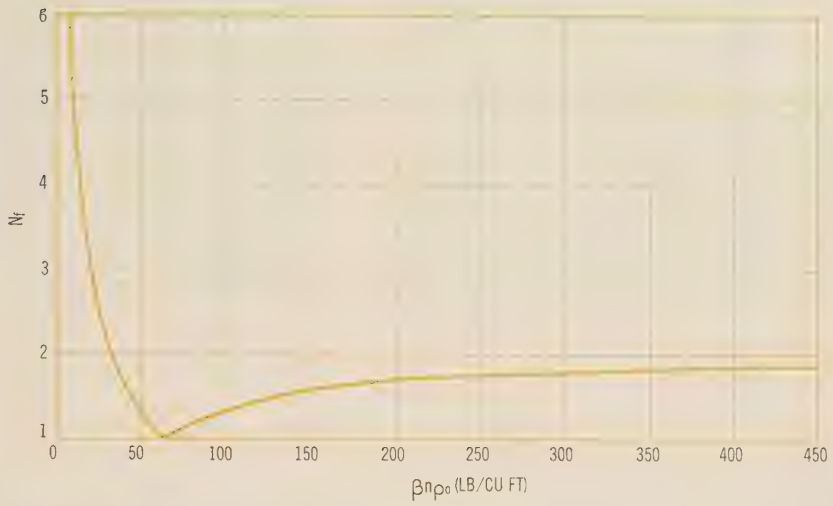



**FIGURE 2:** Limits of the hydrostatic-test non-optimum factor for the barrel section with water as the test liquid.

## Nomenclature

| | |
|---|---|
| A | surface area (sq. in.) |
| D | diameter (ft) |
| L | overall length (ft) |
| $L_s$ | barrel-section length (ft) |
| $N_f$ | hydrostatic-test non-optimum factor |
| n | load factor |
| p | pressure (psi) |
| W | weight (lb) |
| $\beta$ | safety factor |
| $\beta n\rho_o$ | dynamic density (lb/cu in.) |
| $\rho$ | density (lb/cu in.) |
| $\sigma$ | ultimate tensile strength (psi) |

**Subscripts**

| | |
|---|---|
| g | pressurizing gas |
| m | material |
| t | test liquid or total |
| w | welds and weld lands |

## Hydrostatic-Test Non-Optimum Factors

$\beta n\rho_o > \rho_t$ $\qquad$ $\beta n\rho_o < \rho_t$

### Barrel Section

$$p_{top\ theory} = \beta[n\rho_o(D/2) + p_g]$$

$$p_{base\ theory} = \beta[n\rho_o(L_s + D/2) + p_g]$$

$$p_{avg\ theory} = \frac{\beta}{2}[n\rho_o(L_s + D) + 2p_g]$$

$$p_{top\ test} = \beta[n\rho_o(L_s + D) + p_g] - \rho_t(L_s + D/2)$$

$$p_{base\ test} = \beta[n\rho_o(L_s + D) + p_g] - \rho_t D/2$$

$$P_{avg\ test} = \beta[n\rho_o(L_s + D) + p_g] - \rho_t(L_s + D)/2$$

$$N_f = 1 + \frac{\beta n\rho_o - \rho_t}{\beta n\rho_o + \frac{2\beta p_g}{(L_s/D + 1)D}}$$

$$p_{top\ test} = \beta p_g + \rho_t D/2$$

$$p_{base\ test} = p_g + \rho_t(L_s + D/2)$$

$$p_{avg\ test} = \frac{\rho_t}{2}(L_s + D) + \beta p_g$$

$$N_f = 1 + \frac{\rho_t - \beta n\rho_o}{\beta n\rho_o + \frac{2\beta p_g}{(L_s/D + 1)D}}$$

### Upper Dome

$$p_{avg\ theory} = \beta n\rho_o D/4 + \beta p_g$$

$$p_{avg\ test} = \beta[n\rho_o(L_s + D) + p_g] - \rho_t(L_s + 3/4D)$$

$$N_f = 1 + \frac{(\beta n\rho_o - \rho_t)(4L_s/D + 3)}{\beta n\rho_o + 4\beta p_g/D}$$

$$p_{avg\ test} = \rho_t D/4 + \beta p_g$$

$$N_f = 1 + \frac{\rho_t - \beta n\rho_o}{\beta n\rho_o + 4\beta p_g/D}$$

### Lower Dome

$$p_{avg\ theory} = \beta n\rho_o(L_s + 3/4D) + \beta\rho_g$$

$$p_{avg\ test} = \beta[n\rho_o(L_s + D) + p_g] - \frac{D}{4}\rho_t$$

$$N_f = 1 + \frac{\beta n\rho_o - \rho_t}{\beta n\rho_o(4L_s/D + 3) + 4\beta p_g/D}$$

$$p_{avg\ test} = \rho_t(L_s + 3/4D) + \beta p_g$$

$$N_f = 1 + \frac{\rho_t - \beta n\rho_o}{\beta n\rho_o + \frac{4\beta p_g}{D(4L_s/D + 3)}}$$

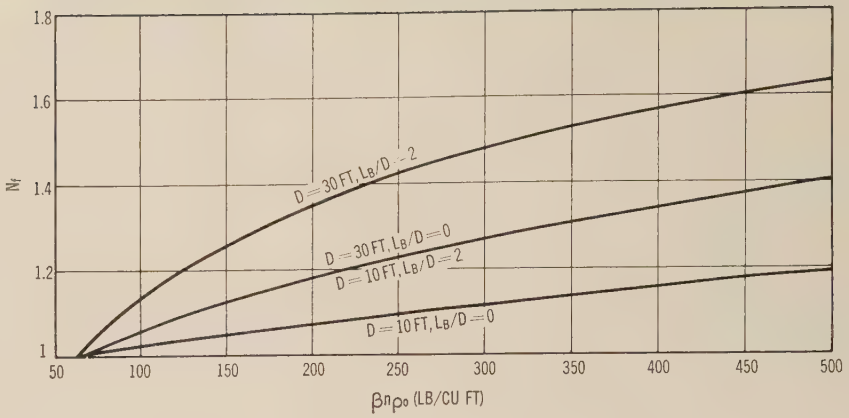
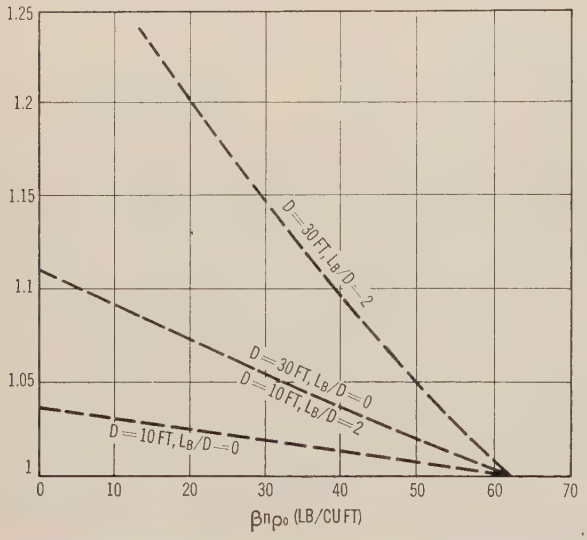
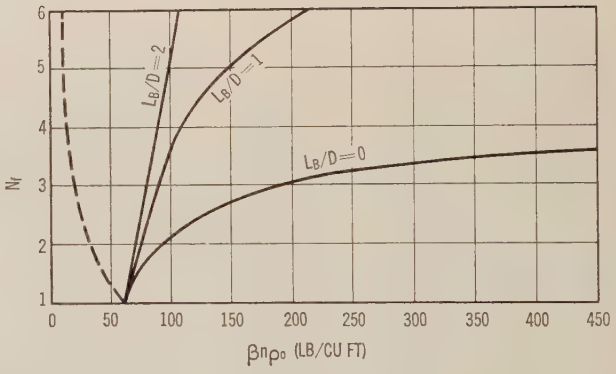



**FIGURE 3:** Limits of $N_f$ for the barrel section (left and below) and the upper dome (below right) at $\rho_t = 62.4$ lb/cu ft and $\beta p_g = 60$ psi.




$N_f$, the hydrostatic test non-optimum factor, can be derived in terms of thickness, allowable stress, diameter, and material density, but all these terms will cancel out.

Our fundamental assumption is that the average theoretical pressure is the base from which deviations from the optimum can be measured. We are further assuming (partly to keep things simple):

- There is a hemispherical dome at each end of the tank.
- The test liquid fills the tank in hydrostatic test.
- The average theoretical pressure is based on tanks completely filled with propellant.
- The maximum ultimate in-flight pressures at any point of a tank occur instantaneously at the time of stage ignition or at the time of maximum acceleration of a preceding stage. This assumption presupposes that a constant differential pressurizing-gas pressure is maintained from ignition to burnout and that the thrust is constant.

*Figure 1* shows that two distinct conditions can exist so far as the test pressure gradient is concerned: $\beta n \rho_o > \rho_t$ (for a test liquid density greatly in excess of the propellant's density) and $\beta n \rho_o < \rho_t$ (for the inverse condition). Values for the average test and theory pressures must be found for both conditions. Because of our definition of $\Delta P_{avg}$, these values are needed before the hydrostatic non-optimum factor can be found. As we have already established the tankage configuration rules, the average test and theory pressures can easily be written in equation form (see *Table*). In the two final equations for each tank section, either $\beta n \rho_o - \rho_t$ or $\rho_t - \beta n \rho_o$ appears. These terms show that, as $\rho_t$ approaches $\beta n \rho_o$ or vice versa, the non-optimum factor becomes unity and the hydrostatic-test disappears.

We now can plot the hydrostatic-test non-optimum factor in terms of both theory and practice. *Figure 2* shows the limits of $N_f$ for the barrel section when water is the testing liquid. The minimum, of course, is unity. The maximum was set by letting $P_g$ approach zero. Under these conditions, $N_f$ for the barrel section becomes:

$$\beta_n \rho_o > \rho_t: \quad N_f = (2\rho_n \rho_o - \rho_t) / \beta n \rho_o,$$
$$\beta n \rho_o < \rho_t: \quad N_f = \rho_t / \beta n \rho_o.$$

For $\beta n \rho_o > \rho_t$ as $\beta n \rho_o$ approaches 62.4 lb/cu ft (the density of water), $N_f$ approaches unity. In a less ideal case like $\beta = 1.5$, $n = 2$, and $\rho_o = 71.1$ lb/cu ft (for lox), however, $N_f$ might be 1.7—hydrostatic testing

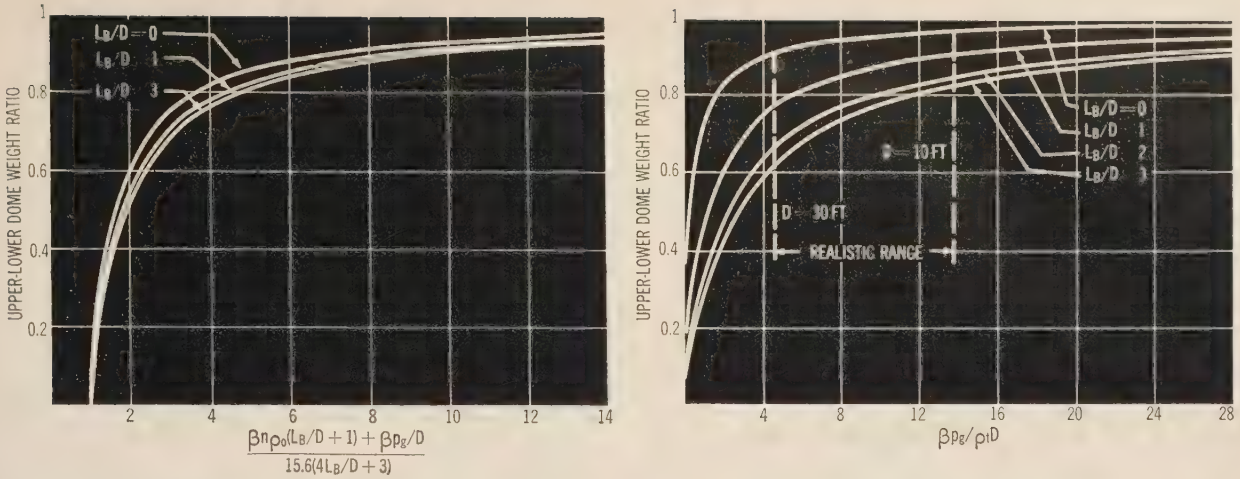



**FIGURE 4:** Weight relationship of the domes at $\rho_t = 62.4$ lb/cu ft and $\beta p_g = 60$ psi for $\beta n \rho_o > \rho_t$ (left and $\beta n \rho_o > \rho_t$ (right).

would impose a 70-per-cent weight penalty. For $\beta n \rho_o = 62.4$ as $\beta n \rho_o$ approaches zero or $\rho_t$, respectively, $N_f$ becomes infinite or again unity. If we don't take an extreme but, say, $\beta = 1.5$, $n = 2$, and $\rho_o = 4.4$ (for liquid hydrogen), $N_f$ becomes 4.73.

In practice, though, none of these cases can occur. If $p_g$ approached zero, for instance, a minimum gage condition would probably exist and make the hydrostatic non-optimum irrelevant. *Figure 3* shows that, in a practical case (and with water as the test liquid), the maximum $N_f$ is 1.6+ for $\beta n \rho_o > 62.4$ and 1.2+ for $\beta n \rho_o < 62.4$ for a barrel 30 ft in diameter and 60 ft long. At $\beta n \rho_o = 62.4$, $N_f$ is unity. *Figure 4* shows the weight relationship between the upper and lower domes if both are designed to $P_+$. As $P_g$ increases relative to $P_+$, the weight of the upper dome approaches that of the lower.

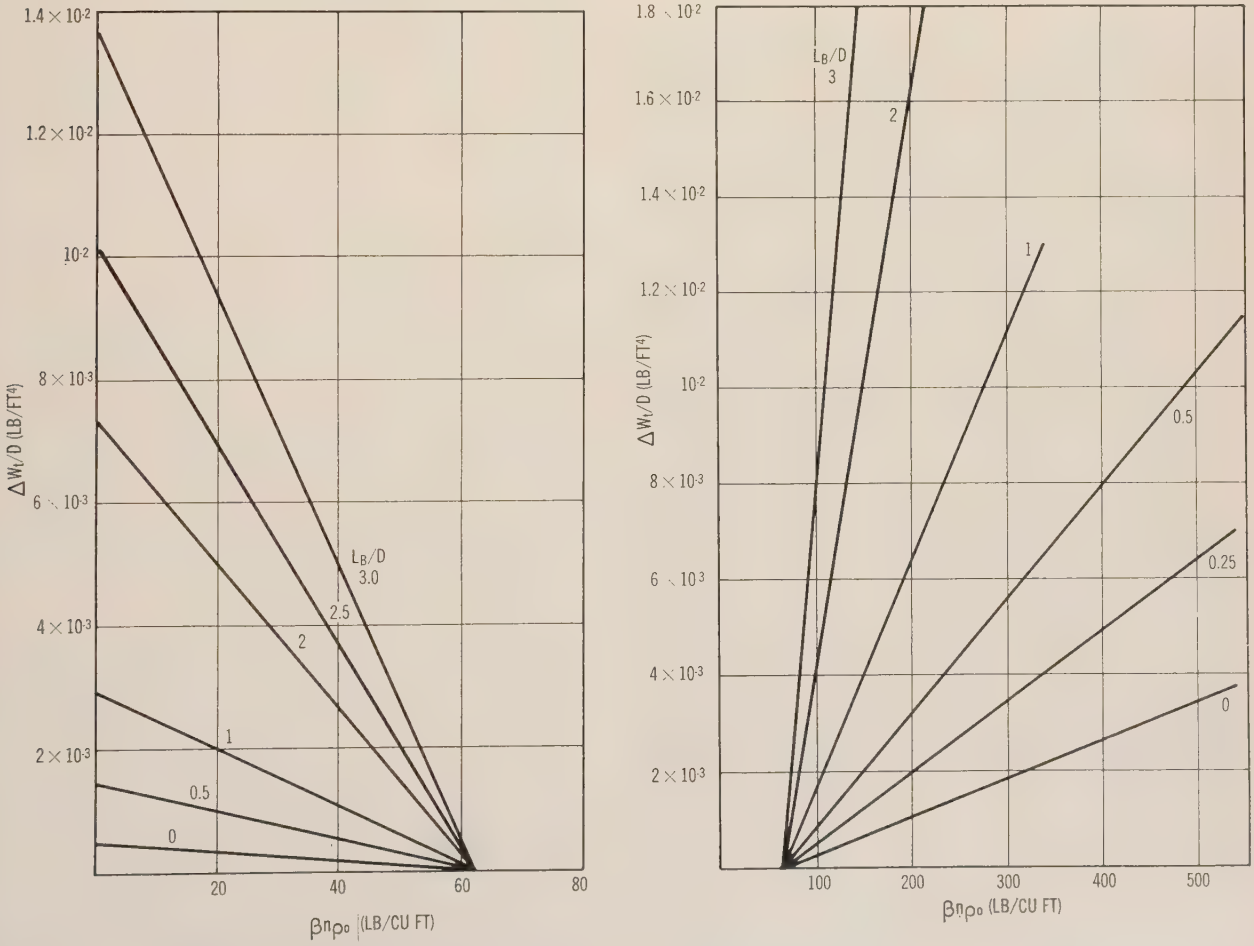



**FIGURE 5:** Hydrostatic-test weight penalty at a test-liquid density of 62.4 lb/cu ft.

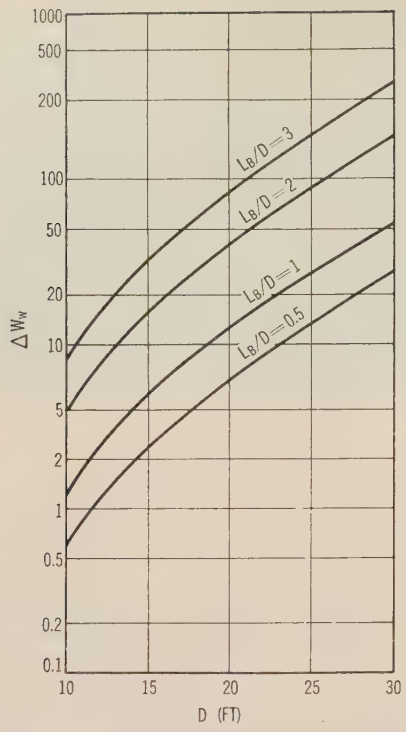



**FIGURE 6:** Weld and weld-land weight penalty due to hydrostatic testing at $\beta n \rho_o = 9.9$ lb/cu ft, $\rho_t = 62.4$ lb/cu ft, and $\beta p_g = 60$ psi.

**HYDROSTATIC-TEST** weight penalty for a single-stage lox-hydrogen booster at various total propellant weights, a safety factor of 1.5, a load factor of 1.25, and a mixture ratio of 5 shows the important effect of the booster diameter.

What does $N_f$ work out to in pounds? The total hydrostatic weight penalty is:

$$\Delta W_t = A_{upper\ dome}\,\Delta p_{avg\ upper\ dome}\,3D\rho_m/\sigma + A_{lower\ dome}\,\Delta p_{avg\ lower\ dome}\,3D\rho_m/\sigma + A_{barrel}\,\Delta p_{avg\ barrel}\,6D\rho_m/\sigma.$$

$W_t$ can be expressed in terms of $\beta n \rho_o$, $D$, $L_B$, and the relationship of $\beta n \rho_o$ to $\rho_t$. For $\rho_t = 62.4$, $\sigma = 60{,}000$, and $\rho_m = 0.1$, we get the data of *Figure 5*. At, say, $\beta n \rho_o = 9.9$ (for hydrogen at $\beta n = 2.25$) and $L_B/D = 2.5$, $10^{-4}\Delta W_t/D^4$ works out to about 86. Now, if $D$ is 10 ft, $\Delta W_t$ is 86 lb. If we increase $D$ to 20 and then to 30 ft, $\Delta W_t$ goes up to 1376 and 6966 lb.

It's true that an $L_B/D$-ratio of 2.5 may not be compatible with any of these diameters. Nevertheless our example leaves no doubt that $\Delta W_t$ is staggeringly high, especially when the tank diameter exceeds 20 ft.

For a two-stage booster, which would be indicated by a 20-ft. lower-stage diameter, the payload weight penalty would be 138 lb, assuming a growth factor of 10. With a 30-ft lower-stage diameter, the payload penalty becomes 700 lb. For a single-stage vehicle (indicated by a 30-ft diameter), the payload penalty would be 6966 lb., or one pound for every pound of hydrostatic-test weight penalty.

So far we have excluded the hydrostatic weight penalty due to weld lands. As *Figure 6* shows, this penalty is small compared with the penalty due to the parent material, but it is not necessarily small in itself—it can go up to 250 lb.

If we don't want hydrostatic-test weight penalties to become a very serious problem for the next generation of boosters, we had better thoroughly review and improve our hydrostatic test requirements and procedures before these boosters appear. It is quite possible that a new approach to the use of safety factors in burst- and proof-testing, coupled with good pressure-testing methods, will rid us of most of the hydrostatic-test weight penalty.

A number of other testing alternatives has been suggested:

- Acceleration simulation on high-g sleds or elevators is expensive and dangerous.
- Testing by gas pressure only is cheap but very dangerous and increases the weight penalty for very dense propellants while minimizing it for low-density propellants.
- Testing barrel section step by step with false bulkheads shows some promise and may prove suitable for very large barrel section. It would, however, still involve a weight penalty.
- Using very dense liquids to test tanks with high dynamic density is very expensive, and there are few suitable liquids (mercury might be suitable for lower domes).
- Differential pressure testing shows much promise, especially for tanks of low dynamic density. Suitable liquids are pure or supersaturated water and other low-density liquids that are neither toxic nor highly inflammable.
- Testing with a combination of split shot and water is all right for lower domes, but for barrel sections it is doubtful whether the simulated hoop tension stresses really duplicate the actual uniform flight pressures.
- Testing a tank in sections before assembly has some merit, but the assembly welds still remain to be tested. Localized testing might, however, suffice for these welds.

# X-15's cryogenic cooling system

## is simple and lightweight

IN BRIEF

*The cryogenic air conditioning and pressurization of the X-15 uses liquid nitrogen metered through fixed-flow control orifices which NAA chose as best suited to a simple, light system spanning appreciable distances within the aircraft. Comprehensive testing was required for the sizing of the orifices—the calculated values proved as much as 100 per cent too high. Special problems that had to be overcome included moisture accumulation during ground checkout and excessive cool-down time for upstream lines.*

**by C. P. Bouman,**
North American Aviation, Los Angeles Div.*

ON A TYPICAL high-performance mission, the X-15 reaches an altitude of over 250,000 ft after launch at 45,000 ft. Atmospheric re-entry occurs at about 100,000 ft. and after pull-out the long glide is made back to the landing. Though the heating rates rise relatively high early in the free flight, it is the atmospheric re-entry and pull-out that drive the ex-

* North American Aviation, Inc., Los Angeles Div., International Airport, Los Angeles 45, Calif.

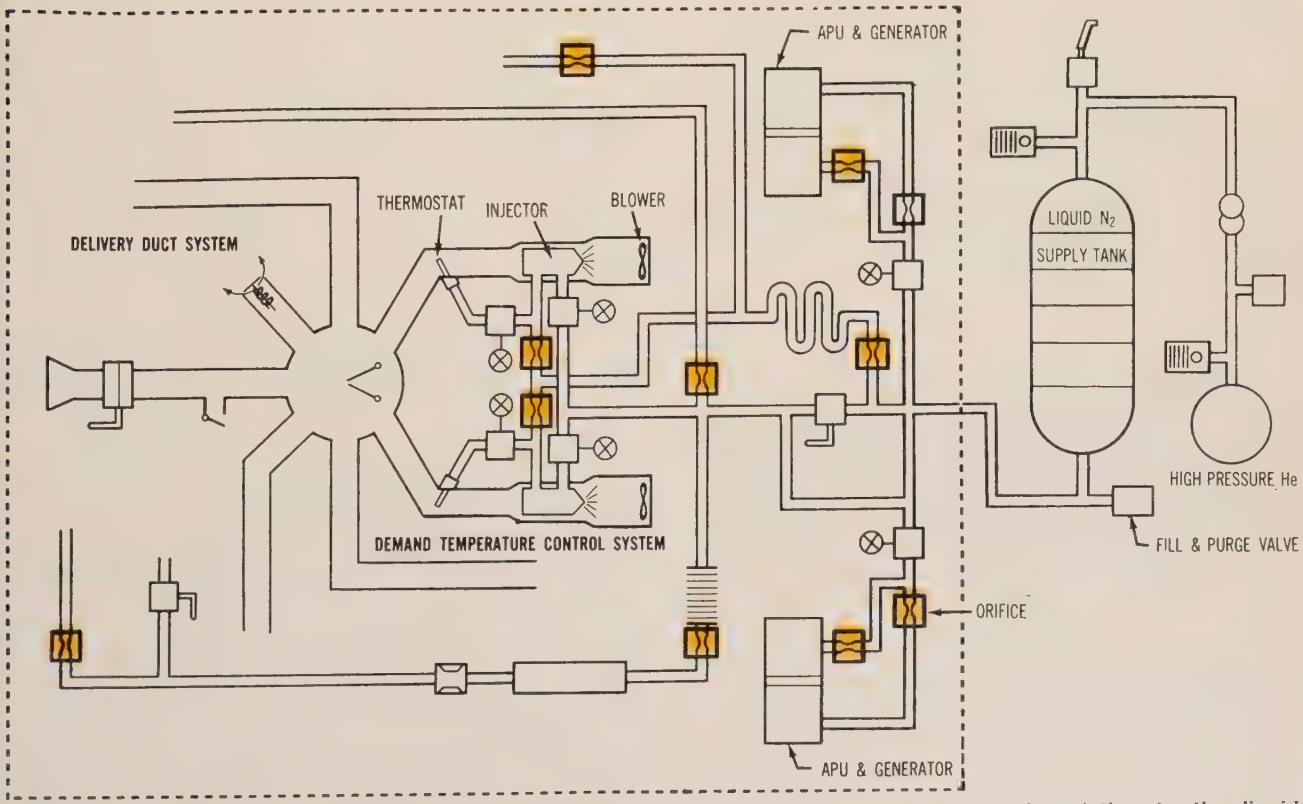



**FIGURE 1:** General layout of the X-15 air conditioning and pressurization system shows the location of the fixed orifices (color blocks) in relation to the liquid-nitrogen supply and the demand temperature system.

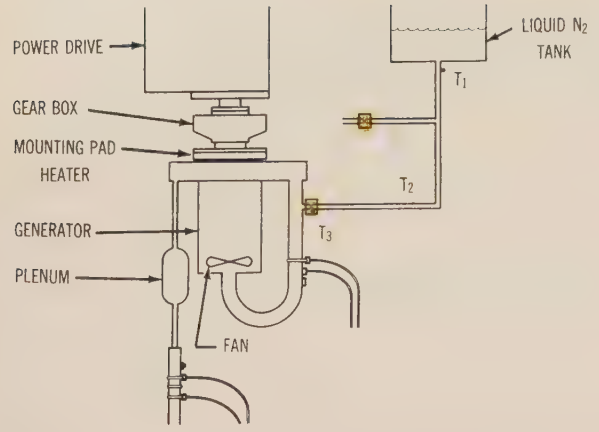



**FIGURE 2:** Test stand used in sizing the flow-metering orifice in the generator cooling line. Temperature measurements at $T_1$, $T_2$, and $T_3$ determined the cool-down time.

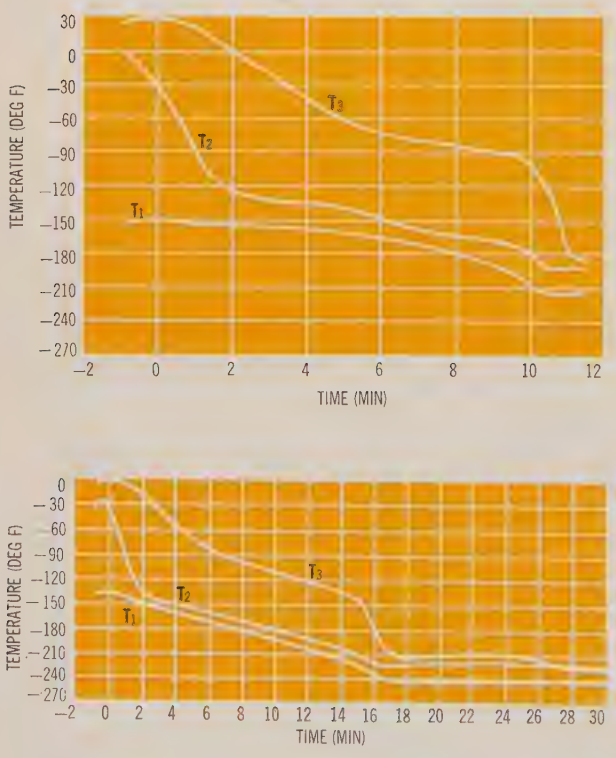



**FIGURE 3:** Cool-down time measured at the test points of Figure 2 with the supply tank pressurized for one minute (left) and 40 minutes (right) before start of the run.

ternal structural temperatures to their peak values of 1200 deg F.

Cooling and pressurization for the pilot's compartment, cooling for the electronics, generators, APUS, and the nose cone, and purge gas for the windshield and hydraulic reservoirs are all provided by the liquid nitrogen system (*Fig. 1*). Liquid nitrogen from the supply tank, pressurized to 70 psi with helium, is forced through the main supply line to the demand-type temperature control systems and injected into the recirculated cabin gas. This gas is forced through the mixing chambers by axial blowers, ducted to the electronics for cooling, and discharged into the cockpit for pressurization. Branch lines from the main supply line fill the other cooling and purge requirements. All gas flows are controlled by fixed orifices inside the lines.

We decided on fixed orifices as the flow metering devices because they would give us a simple and light cooling system with low power consumption for equipment with a relatively constant heat load. Closer temperature control, using pneumatic or electric metering devices, would have meant additional valves, relays and plumbing. That some of the X-15 components that need cooling are remotely located would have made this job doubly difficult.

## Fixed-orifice design is complex

While the fixed-orifice system is simple in operation, the design isn't. The orifices had to be sized to provide maximum coolant flow at just about the time when maximum cooling is required. The question of orifice location with respect to the supply also is quite complicated: if the orifice is close to the liquid source, liquid flow starts quickly and may lead to over-cooling. Smaller orifices correct this problem, but there is a minimum size below which the danger of contamination and blockage becomes too great.

The conditions that affect the minimum cooling flow requirement and therefore the sizes of the flow control orifices cannot all be integrated into a comprehensive problem statement and solved analytically. There are too many transient factors connected with supply-line lengths, insulation effectiveness and line cool-down time, temperature ambients, and the heat capacities of the components requiring cooling. Orifice sizes determined by calculations are approximations at best and cannot replace a comprehensive test program.

*Figure 2* shows our generator cooling system test stand, typical of the stands used in the test program to determine orifice sizes. The generator was insulated to make sure that all the heat it developed would have to be removed by the coolant flow. A second orifice and separate ducting simulated flow to the second generator. The heat input from the generator drive pad of the APU was simulated by an electric heater that raised pad temperature to 250 deg F in 12 minutes.

Our calculations showed that a 0.018.-in-diameter orifice could provide the flow necessary for cooling the generator. Test runs were made with the liquid-nitrogen tank pressurized for 1, 40, and 90 minutes before the start. Line cool-down until there was a liquid or a highly saturated gas flow at the orifice took about 10 minutes after the start of the run for one-minute pressurization and about 15 minutes for 40-minute pressurization (*Fig. 3*). Both tests had to be stopped because of overcooling.

The 90-minute pre-pressurization—which is closer to

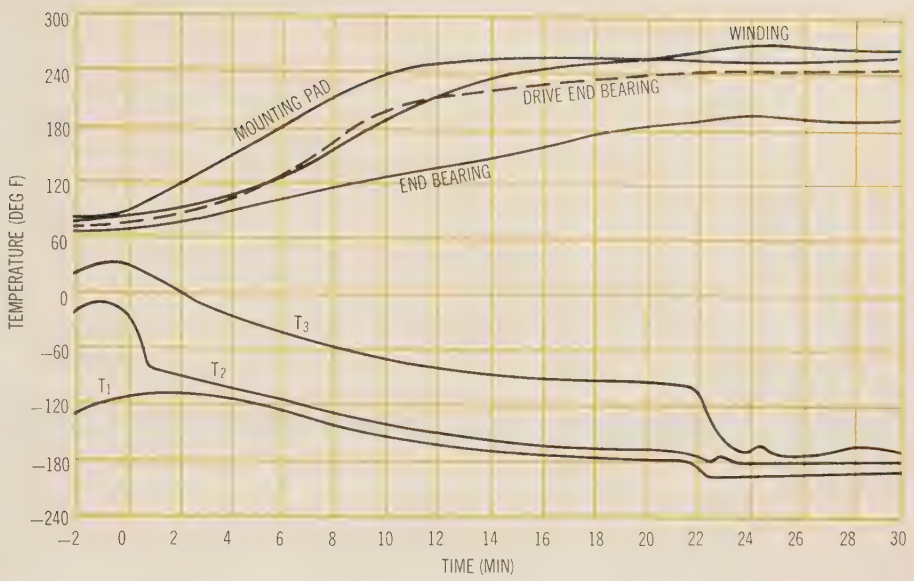



**FIGURE 4:** Cool-down time in generator tests with the supply tank pressurized 90 minutes before start of the run.

the actual operating conditions under which the saturation temperature of liquid nitrogen at 70 psi is reached—was then used for a series of tests. The first run showed that the coolant flow through the 0.018-in. orifice gave marginal results, and an 0.022-in. orifice was installed. Liquid flow reached this larger orifice about 22 minutes after the start of the run and the temperatures at critical points had stabilized or were dropping at the end of 26 minutes (*Fig. 4*).

The liquid-nitrogen consumption was measured during the tests by weighing the supply tank and also by passing the exhaust gas through a plenum and a volumetric gas meter. These two methods gave results that agreed within four per cent. Our calculated values agreed well with the actual flows during the cool-down period but were more than 100 per cent too high for the steady-state conditions (*Fig. 5*). We also found that the steady-state flows were identical for the 40- and 90-minute pressurization periods.

The location of the flow-limiting orifice with respect to the supply has an especially critical effect on line cool-down time when flows are less than 0.25 ppm. Ground tests of the X-15 showed that so much was needed for cooling down the upstream lines that no adequate component cooling could be provided. We therefore had to reduce the cool-down time by pre-cooling the upstream lines.

Pre-cooling is done by the demand temperature control system downstream of all the fixed-flow orifice systems (*Fig. 1*). It has a thermostatically-controlled variable-area flow control that reduces the cool-down time quite effectively by passing the initial high gas flows. The demand system is started before any of the X-15 components whose cooling is controlled by fixed orifices.

## frosting, icing were problems

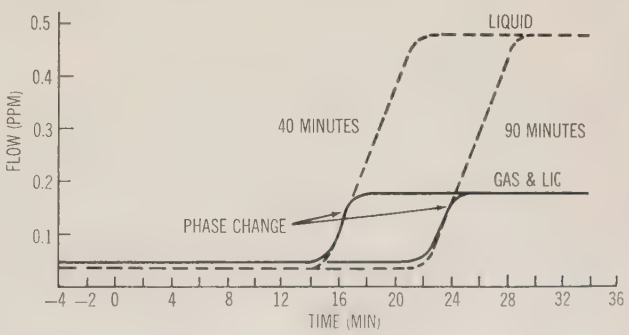
Frosting and icing during ground checkout were another problem. It's almost impossible to design a system that doesn't breathe, and breathing means moisture gets in. The problem is made worse if you have a low-mass-flow system with flow controls and lines of small diameter. Nor does it help that the X-15 ground checkout is run one to two days before a flight. The frost that accumulates during the ground runs melts and results in a moisture-saturated system at the end of the run. The system must be purged to remove the moisture before re-servicing.

We took three steps to prevent ice blockage.

- A hot-nitrogen gas purge is made before servicing the system.
- Solenoid-operated, energize-to-close-type shutoff valves were used wherever possible, so that the heat from the solenoid would keep the valve from freezing during long standbys.
- Valves with continuous, controlled leakage were used to provide system purge during standby.

The heat input from the hot-gas purge and the solenoid valves increases the line cool-down time, but this is partly offset by the gas flow through the continuous-bleed valves which reduces the cool-down time in addition to purging the lines. The low bleed flow of 300 $cm^3$/min doesn't affect the system capacity unless many valves of this type are used.

**FIGURE 5:** Theoretical (dashed curves) and experimental (solid curves) cooling fluid flow to the generator for two pressurization periods before start of the run.



by **Irwin Stambler,** Associate Editor

# Semiconductor strain gages:

## small size, high output

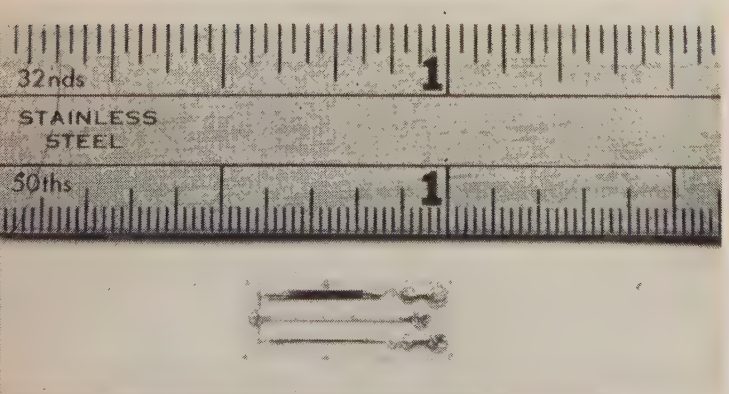
THE SEMICONDUCTOR strain gage promises to do for testing what the transistors and other semiconductor devices have done for electronics. Though only a few companies so far have marketed commercial strain gages of this type, many more are likely to make them in the years to come.

The conventional resistance strain gage is based on the "piezoresistive effect" in metals, which was first studied by Lord Kelvin: A change in electric resistivity occurs when stress is applied. In the early fifties, researchers at Bell Telephone Labs and Case Institute of Technology discovered that semiconductor materials also show this piezoresistive effect. Of course, all materials show it to some extent, but the researchers discovered that the piezoresistive coefficients for materials like germanium and silicon are extremely high. The gage factors for these semiconductors go up to 175, as against 2-5 for metallic wires.

These findings were reported by C. S. Smith, of Bell Labs in a paper in 1954, but went generally unnoticed. One of the few companies to begin research in this area was Micro Systems, Inc., 319 Agostino Rd., San Gabriel, Calif.

In strain gages, as in all other applications, semiconductors offer the advantage of greatly reduced gage size and weight. Furthermore, engineers at Micro Systems pointed out to SPACE/AERONAUTICS, you can take some of the 50 or 60 times higher output ratio of semiconductor strain gages and trade it for frequency response in transducer designs. Using the same output you would get from a conventional strain wire you can get eight times the natural frequency.

Its single-crystal structure keeps the semiconductor almost completely free of hysteresis, providing excellent repeatability. The mechanical stability of the material at both room and high temperatures helps to minimize




**"MICRO-SENSOR"** semiconductor strain gage made by Micro Systems is self-temperature-compensated, designed for mounting on aluminum, and has a P-type strain filament with a positive gage factor and an N-type filament with a negative gage factor. Both filaments have a positive temperature coefficient.

**Semiconductor vs Metallic Foil Gages**

| | Semiconductor Gage | Metallic Foil Gage |
|---|---|---|
| Gage factor | 130 | 2 |
| Typical "apparent strain" on steel (uncompensated gages, microstrain/deg F) | 6-8 | 6-10 |
| Thermal coefficient of expansion (ppm/deg F) | 1-3 | 5 |
| Thermal coefficient gage factor (per cent per 100 deg F) | 10 | 1 |

## IN BRIEF

*As long ago as 1953, it was discovered that semiconductors show unusually strong piezoresistive effects in comparison with metallic elements. Yet it's only been in the past two or three years that industry has become aware of the possibilities this finding offers for strain-gage design. Now a wide variety of applications for semiconductor strain elements is opening up, ranging from static and dynamic strain gages to high temperature sensors and pressure transducers.*

*The advantages of semiconductor strain gages lie in their small size and high output and in the possibility of producing them by solid-state diffusion. They have proved suitable for measuring very small strains and conventional strain levels with high outputs. In design, they are already progressing from conventionally bonded units to flexible-joint and weldable types.*

creep as well as hysteresis effects.

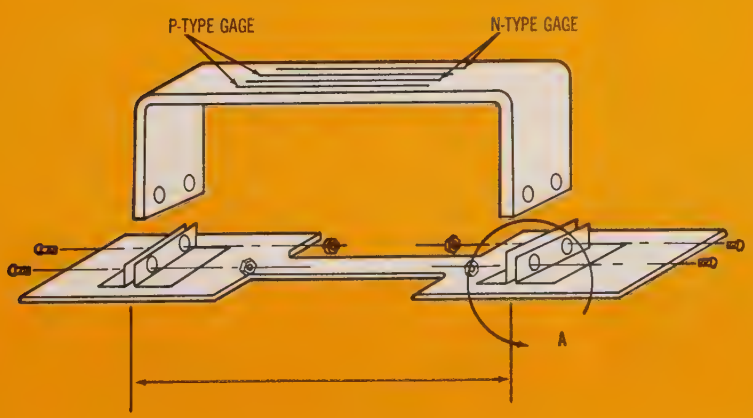
The semiconductor gage so far has found two principal applications in experimental stress analysis:

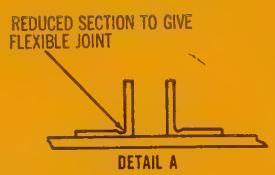
- The measurement of very small strains—on the order of several microinches—for which the new device, besides providing high sensitivity, also has the advantage of a high signal-noise ratio;
- The measurement of conventional strain levels—say, 2500-3000 in.—at which the output of a conventional gage is in the order of a few millivolts but the semiconductor gives up to five volts.

An example of the first kind of application came in the X-15 engine mount tests. There had to be a preload of 10,000 lb, which was easily measured with conventional gages. But then ±100 lb had to be measured and for that preload, semiconductor gages proved best. In another case, a very large impact force was generated in a supersonic wind tunnel and a very small force about it had to be measured with great accuracy. A four-arm bridge of semiconductor gages provided an accuracy of better than ½ per cent.

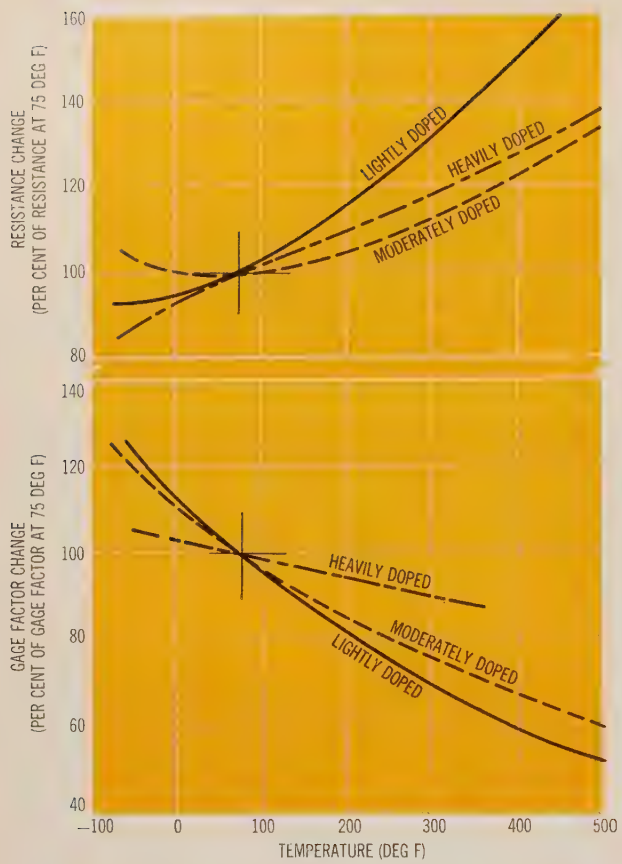
In the design of a force cell for missile tests, the high output of semiconductor gages proved important. The missile had to be shaken at a full-scale load condition of 50 lb. The test engineers wanted to measure the load coming off at various points and wanted enough output from the force cell to get to an oscilloscope without amplification. Using semiconductor gages, they got a 250-mv signal with a 20-V input for the 50-lb force.

As semiconductor crystals can be either P- or N-types, sensors can have a positive or a negative gage factor. By using positive and negative sensors as the adjacent arms of a bridge circuit, strain sensitivity can be doubled. Since both strain filaments can be provided with positive temperature coefficients of resistance,




**"STRAINDUCER"** semiconductor transducer, made by Electro-Optical Systems, is essentially a four-active-arm, bonded strain gage. It is used to measure elongation and strain at up to 700 deg F.




**EFFECTS** of temperature on the basic performance of silicon strain gages. The resistance values are based on tests of unbonded units; the gage factors, on tests of units bonded to 17-4PH steel.

this arrangement also can provide temperature compensation.

One of the newer gages has four arms on a single carrier to provide a full Wheatstone bridge with a quadruple output. At a strain (tensic or compressive) of 2500 in./in., the output is five volts DC with an input of 20 V DC. Such a unit is directly compatible with existing telemetering systems without requiring an amplifier.

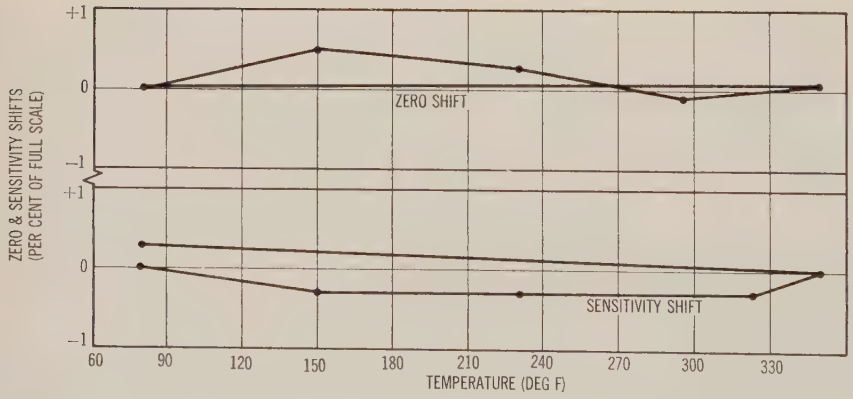
As might be expected, a number of limitations cropped up in early semiconductor gage designs (some of which have been at least partly overcome by now). These included relatively high temperature coefficients of resistance, or "apparent strain," gage factor change with temperature, brittleness, and lack of filament flexibility.

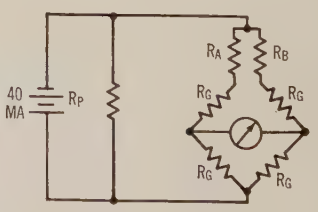
Closer control of production processes and 100 per cent testing of filaments, Micro Systems states, has eliminated problems due to random material imperfections. Improved production processes and new gage configurations—like the U-shape with both leads at one end—are said to have markedly reduced some of the problems of brittleness and flexibility. The U-design has a larger surface at the end tabs to serve as an anchor, minimizing adhesive shear stresses and reducing hysteresis, creep, and transverse strain sensitivity at room and elevated temperatures.

## Gages bend around small radii

The U-gage is available as an unbonded filament or on high temperature epoxy-glass carriers. The latter can be used statically to 400 deg F and dynamically to 500 deg F. With the backing, the gage reportedly can be bent and installed around radii as small as 0.125 in.

The use of solid-state diffusion methods in making the gage elements, reports J. C. Sanchez, of Micro Systems, has also expanded the range of gage applications. For instance, a U-gage made in this way (instead of being built up of silicon) has a gage factor much less sensitive to temperature. The slope of gage-factor change vs temperature change, says Sanchez, has




**SIMPLE** compensating bridge network devised by A. S. Moen, of Micro Systems, for a pressure transducer shows how the temperature sensitivity of semiconductor sensors can be overcome by careful gage selection and good overall design. The total error bandwidth for zero and sensitivity shift is about one per cent of full scale over a 300-deg F range. The full-scale sensitivity of the transducer with a shunted constant-current power supply is one volt of output at a ten-volt input at room temperature. The resistances of the network are: $R_A = 13.5$ ohms, $R_B = 30.2$ ohms, $R_G = 2.5$ ohms, $R_P = 3000$ ohms.

been reduced from over 12 per cent per 100 deg F to less than five per cent. However, this has been achieved at the expense of a gage-factor reduction from 120 to 60. Even at 60, though, this factor is still some 30 times that of metallic gages, Sanchez points out.

Diffusion techniques also make it possible to take advantage of the semiconductor junction's ability to electrically isolate and insulate a part of the semiconductor. For instance, a P-layer can be formed by the diffusion of dilute P-impurities like boron onto the surface layer of an N-type gage of a silicon transducer element.

In filament fabrication, Sanchez states, it's hard to get high resistance values for low-resistivity materials. With the diffusion method, the electrically effective layer of a filament consists only of the heavily doped P-section, so that you get an equivalent thickness much smaller than that of standard units and higher terminal resistance for a fixed resistivity value.

## Temperature gages can be made

Doping techniques make semiconductors highly suitable for temperature sensors. In the past, designers were stuck with the resistivity ($\rho$) of the metallic wire —whose resistance ($R$) equals $\rho L/A$. All the wire in the gage had the same resistivity. Basically, therefore, a certain length was required for conventional strain gages if you wanted to get the desired resistance. Designing $R$ by $L/A$ made it difficult to get short gages with high resistance. For temperature sensors, the problem was even worse, because in that case large and small masses give widely different results. To get the shortest response time, therefore, the smallest ratio of surface area to mass ratio was needed.

With silicon, however, the resistivity itself can be varied (instead of the cross-sectional dimensions), and that by five orders of magnitude. Reportedly it's very easy to make a gage 0.1 in. long and 0.01 in. wide for any value between 10 and 10,000 ohms. The unit provides high impedance with a very large output. Using only one sensor in a Wheatstone bridge leg, for example, it's possible to get five volts per 500 deg F.

Sanchez and W. V. Wright, of Electro-Optical Systems (Micro System's parent company), report that semiconductor gages have a lower drift rate at 700 deg F than do metallic units. So far, however, conventionally bonded semiconductor gages are limited to strain levels of less than 3000 in./in. The maximum useful strain levels of such a unit are also limited by the expansion rate of the base metal. On the other hand, the flexible joint design of Electro-Optical's "Strainducer"—essentially a four-active-arm unit—makes it possible to measure up to 60,000 microstrain at room temperature and 5000-10,000 microstrain at 700 deg F. The output voltage at full-scale strain is five volts DC for an input voltage of 20-25 V.

Several transducer manufacturers are using semiconductor gages in their units. A typical 0-500-psi pressure transducer of this type has an output of five volts DC (at full-scale pressure and a 25-V DC input) and a total deviation of less than one per cent.*

Semiconductor gages have also been used in a number of airborne applications. Several hundred of them are being used in a current satellite series and transducers using semiconductor sensors have been used in telemetering units surgically inserted in animals.

Semiconductor gages on weldable metal strip are being added to the bondable types that have prevailed up to now. These new units are being made in sizes ranging from ¼×½ and ⅛×½ in. down to 0.08 in. in length and 0.06 in. in width. High temperature weldable sensors are being developed for temperatures of up to 500 deg F and eventually are expected for up to 1500 deg F.

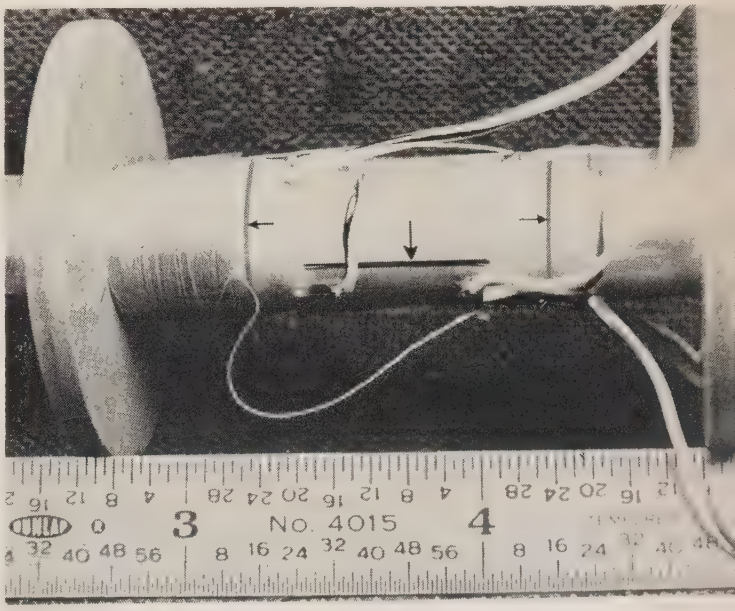
Work on sensors to take temperatures of up to 2000-3000 deg F is in the early R&D stages. These units might use materials like silicon carbide. Work is also continuing on ever smaller devices—an 0.002-in. wide sensor has already been built.

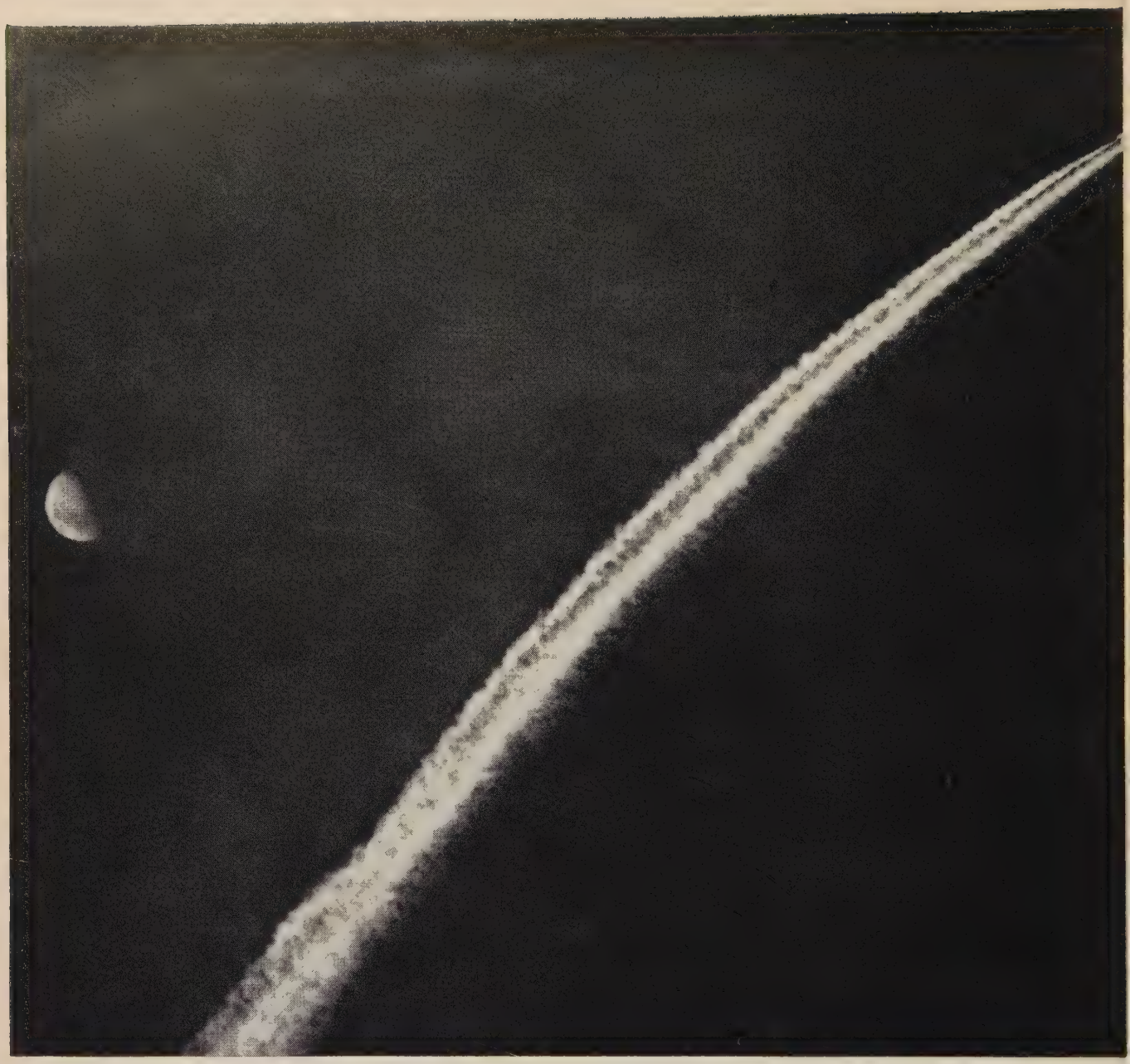
* Other performance data: overload, 50 per cent; repeatability, 0.1 per cent of full scale; non-linearity, 0.5 per cent of full scale; maximum hysteresis, 0.25 per cent of full scale; temperature range, −65 to +300 deg F; thermal sensitivity shift, ±0.2 per cent of full scale per 100 deg F from −65 to +250 deg F; thermal zero shift, ±0.2 per cent of full scale per 100 deg F from −65 to +250 deg F; combined temperature effect, ±0.25 per cent of full scale per 100 deg F from −65 to +250 deg F.

## References


*Smith, "Piezoresistive Effects in Germanium and Silicon,"* Phys. Rev., *Apr. 1, '54.* ■ *W. P Mason, R N. Thurston, "Use of Piezoresistive Materials in the Measurement of Displacement, Force and Torque;"* J. Acoustical Soc. Am., *vol. 29, '57.* ■ *F. T. Geyling, J. J. Forst, "Semiconductor Strain Transducers;"* Bell System Tech. J., *vol. 39, '60.* ■ *E. D. Padgett, Wright, "Silicon Piezoresistive Devices;" Instr. Soc. Am., Preprint NY60-42. Sept. '60.* ■ *Sanchez, "The Micro Sensor, A New Tool for the Experimental Stress Analyst;" Soc. Exp. Stress Analysis, Oct. '60.* ■ *Sanchez, Wright, "Recent Developments in Flexible Silicon Strain Gages;" ISA Meeting, St. Louis, Mo., ISA Paper 37-SL61, Jan. '61.* ■ *Sanchez, Wright, "Recent Advances in Flexible Semiconductor Strain Gages;" Los Angeles, Calif., Sept. ISA Preprint 46-LA61, '61. A. S. Moen, "New Horizons in Transducers Utilizing Solid State Strain Gages;" ISA Preprint 114-LA61, Sep. '61.*


**SEMICONDUCTOR** strain gages (arrows) attached to a load link for dynamic testing of missile components. Forces of up to 50 lb full scale are measured with a 250-mv output. No amplification is needed for oscilloscope readout. The gages are temperature-compensated from 30 to 130 deg F.





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**by A. E. Gallagher and A. O. Ingelse,**
Section Head & Engineering Specialist, Analytics Dept., Goodyear Aircraft Corp., Arizona Div.*

# Drop tests prove out inflatable lunar decelerators

THE IDEAL "landing gear" to stabilize a vehicle during a lunar and planetary descent and absorb the landing shock, our studies show, is a large, inflated fabric cushion shaped somewhat like a doughnut. To suspend such a "decelerator," short linkages extend from the periphery of the payload (*Fig. 1*).

The decelerator developed by Goodyear is made of a special lightweight, laminated, and tear-resistant fabric. Its compartmented tori are separately inflated with gas just before landing. Upon impact, a quick-release device rapidly deflates part of the decelerator structure to dissipate the impact energy and prevent rebound. The vehicle then settles to the surface, cushioned by the partly inflated decelerator.

In actual operation, deflation will occur through a frangible orifice; on our test vehicle, which of course could not be a one-shot design, we used a light plug and 0.050-in.-diameter shear pins. Furthermore, in place of the payload this full-scale model had a lightweight, welded aluminum superstructure (*Table I & Fig. 2*). Generally this model was designed on the basis of scaling laws derived to simulate the dynamic characteristics of a moon landing.

Test model characteristics are listed in *Table II* and test area geometry is shown in *Figure 3*. It weighs 134 lb and has a mass of 4.16 slugs, or one-sixth of the

* Goodyear Aircraft Corp., Arizona Div., Litchfield Park, Ariz.

**Table 1: Test Model Characteristics**

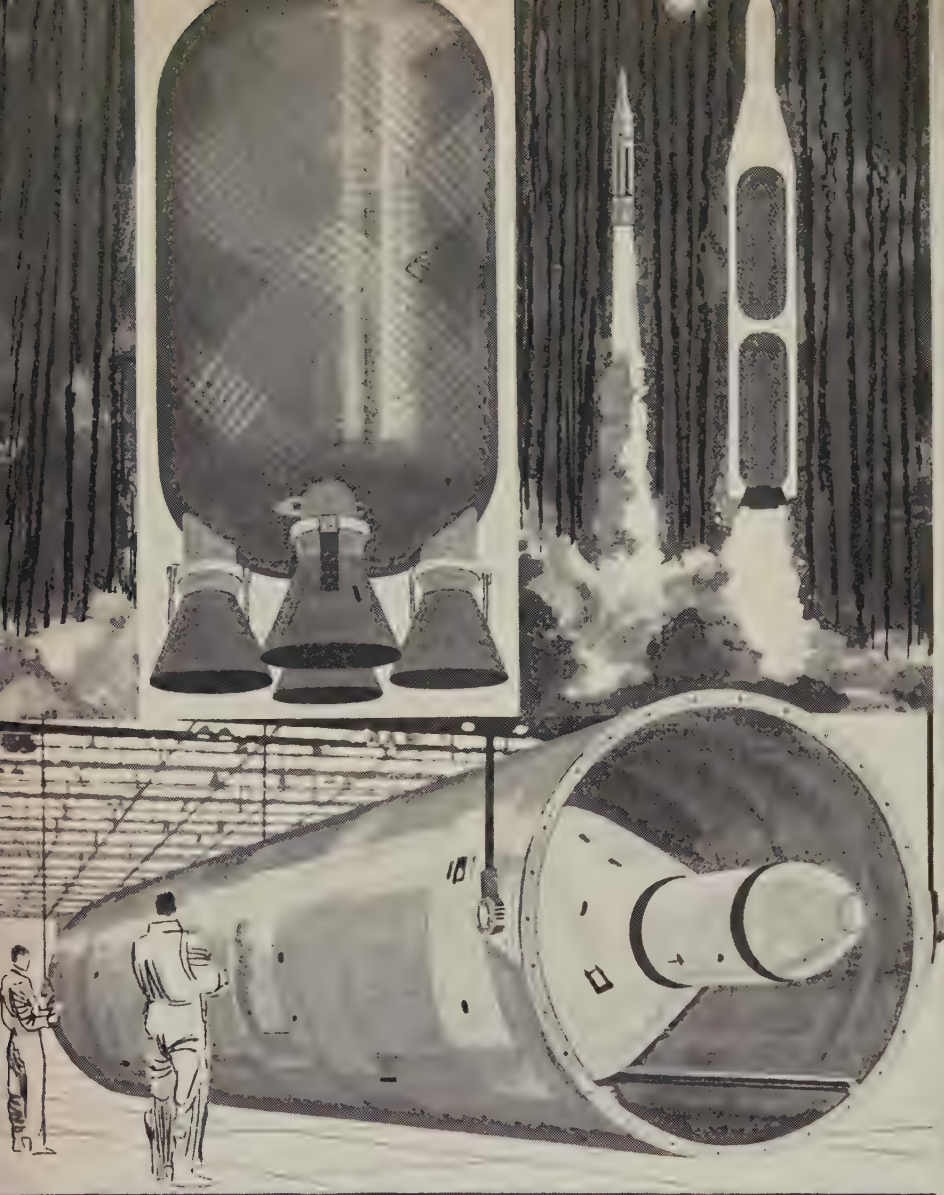
| | |
|---|---|
| Vehicle mass | 4.16 slugs |
| Vehicle pitch moment of inertia | 19.1 slug-sq ft |
| Decelerator mean torus diameter | 6.85 ft |
| Decelerator cross-sectional diameter | 1.5 ft |
| Decelerator volume | 37.62 cu ft |
| Orifice diameter | 14.92 in. |
| Orifice area | 1.21 sq ft |
| Mass-volume ratio | 0.11 slugs/sq ft |

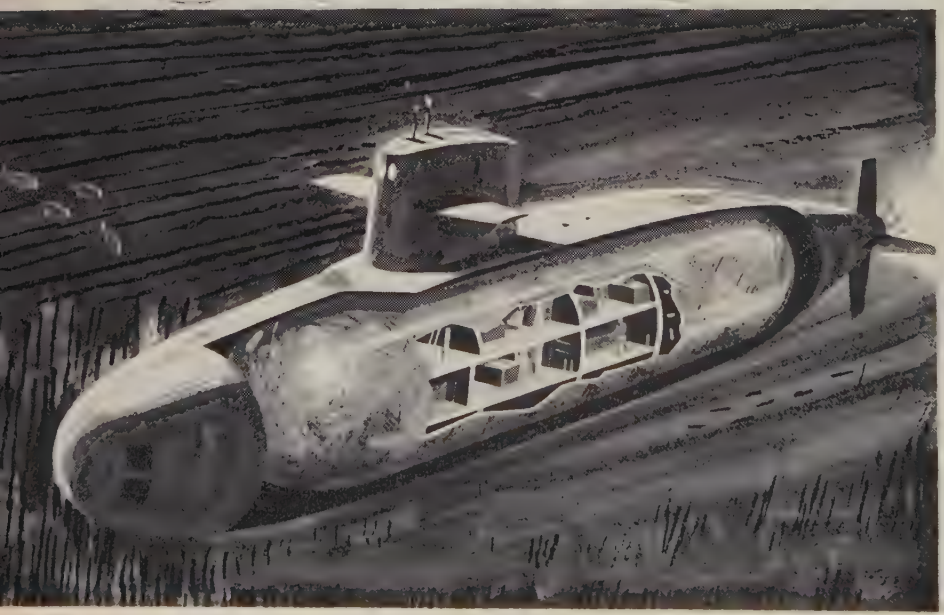
**FIGURE 1:** Landing of lunar payload equipped with an inflatable decelerator. The decelerator would be inflated and extended only during the very last part of the descent.

IN BRIEF

*For soft landings on the moon and planets, a pneumatic decelerator system has been developed that provides the stability and shock absorption required for a space payload. A model, scaled to simulate the actual forces of a landing on the moon, has been put through an extensive drop test program.*

*The test results show that a segmented torus that deflates partly on contact with the surface provides optimum landing characteristics, dissipating the impact energy and preventing rebound. A frangible quick-release orifice is used for deflation. The test data also agreed well enough with the theoretical values to prove out the analytical method used in the design of the decelerator.*





# THE WONDER MATERIAL FOR ADVANCED CONCEPTS IS PLASTICS

## ...AND PLASTICS MEAN ZENITH

The Zenith-developed method of end over-end filament winding is ideal fo advanced concepts for missile cases rocket motor containers, and dee diving submersibles. A case in point i Zenith's capability of tension-windin cases up to 12 ft. x 85 ft. No othe company in the United States ca wind cases of this size.

Zenith's technique utilizes glass fi aments pre-impregnated with resin t form these structures. During th process the glass is protected by th resin, minimizing the possibility o undetected fracture. This assure more uniformity and reproducibilit

Exact manufacturing quality assu ance can be exercised from basic glas filament to completed structure.

Before you seal the design, conside the many benefits of plastics for you projects. Remember, the wonde material for advanced concepts is pla tics...and plastics mean Zenith.

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**Table II: Representative Drop Test Results**

| Ground Surface Slope (deg) | Vertical Impact Velocity (fps) | Blowout Pressure (psig) | Max. Pressure (psig) | Rise time to Max. Pressure (sec) | Max. Deceleration (g)* | Max. Onset Rate (g/sec) |
|---|---|---|---|---|---|---|
| 0 | 20 | | 1.78 | 0.055 | 37.4 | 3000 |
| 0 | 24 | | 1.94 | 0.057 | 37.2 | 2555 |
| 15 | 20 | 1.02 | 1.18 | 0.127 | 13.2 | 1125 |
| 15 | 24 | 1.02 | 1.74 | 0.112 | 16.1 | 1333 |
| 15 | 28 | 1.58 | 2.18 | 0.110 | 19.0 | 1800 |
| 15 | 31 | 0.95 | 2.00 | 0.094 | 24.0 | 2840 |
| 15 | 34 | 0.40 | 2.60 | 0.108 | 29.2 | 3760 |

* In an actual moon landing, all values would be smaller by five-sixths.

mass of an actual moon vehicle. The acceleration load factors used with this model therefore were six times greater than those to which the moon vehicle will be exposed. The test drop heights naturally also were chosen to duplicate lunar conditions.

Pressurization and the orifice through which gas is exhausted had to be adjusted to compensate for the presence of atmosphere as well as for the foreshortened time of descent. The time differences between a terrestrial test drop and the actual moon landing affect the relationship of orifice-opening time to peak-pressurization time—under certain drop conditions, peak pressure occurs after the shear pins have been severed.

To measure the dynamic forces present during a test drop, considerable instrumentation is required: pressure transducers, accelerometers, an 18-channel oscillograph, a blow-out shear-pin resistance circuit, and high-speed (1000-3000-fps) motion picture cameras aimed at a large, bright yellow backdrop with an accurate grid of fine black tape.

*Table II* and *Figure 3* show some representative drop test results. These data well enough agree with theoretical, computed values to prove that the performance of our type of decelerator can be predicted analytically.

**FIGURE 3:** Test results for a 24-fps impact on a 15-deg slope.

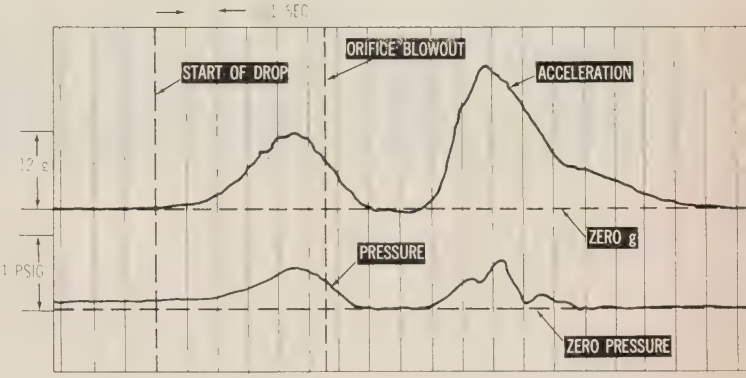
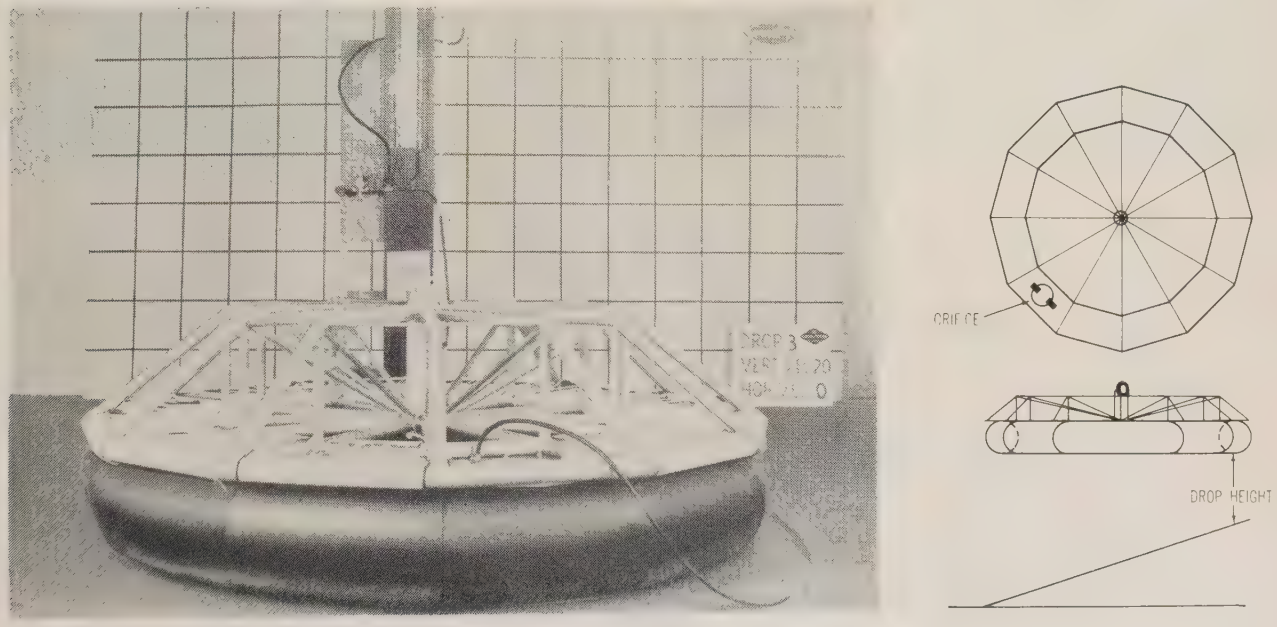
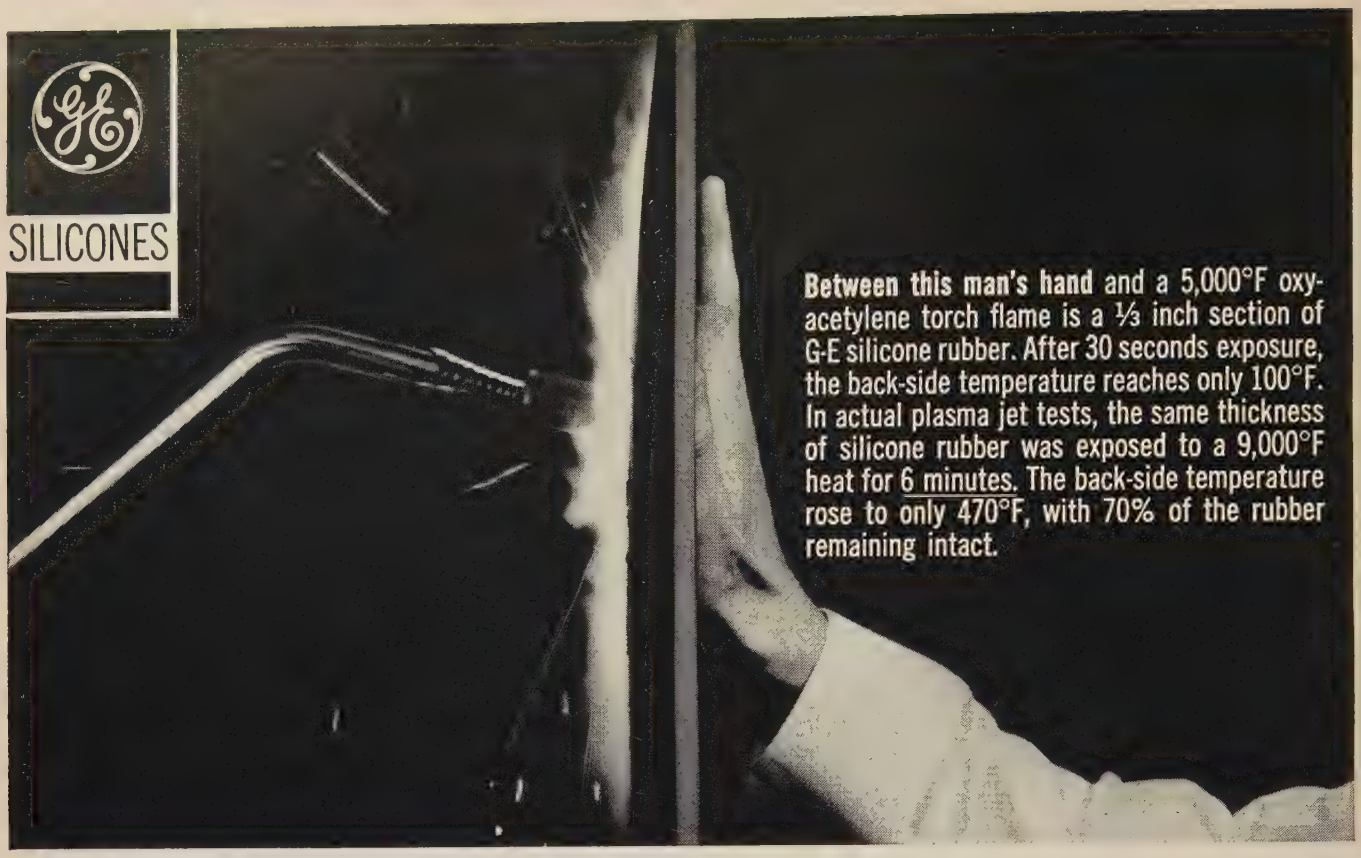



**FIGURE 2:** Full-scale test model of Goodyear lunar decelerator with aluminum superstructure. The background grid in the test setup is used in high-speed motion picture studies.



SILICONES



**Between this man's hand** and a 5,000°F oxy-acetylene torch flame is a ⅓ inch section of G-E silicone rubber. After 30 seconds exposure, the back-side temperature reaches only 100°F. In actual plasma jet tests, the same thickness of silicone rubber was exposed to a 9,000°F heat for 6 minutes. The back-side temperature rose to only 470°F, with 70% of the rubber remaining intact.

# *Thermal barrier against 5000°F flame*

## *GENERAL ELECTRIC SILICONE RUBBER*

**RESULTS OF PLASMA JET TESTS AT 9,000°F**

Flight Simulation
Vel. = 17,000 ft./sec.
Alt. = 250,000 ft.

| Exposure time at 9,000°F | Back-side temperature of ⅓ inch section of G-E silicone rubber |
|---|---|
| 30 seconds | 100°F |
| 2 minutes | 210°F |
| 3 minutes | 300°F |
| 4 minutes | 375°F |
| 5 minutes | 430°F |
| 6 minutes | 470°F |

**The surface of the tested rubber section** forms a hard, carbonaceous crust, while the underside remains flexible and undamaged. Preliminary tests showed the effective heat of ablation to be eight times better than presently used plastics, with one-seventh the rate of ablation and one-fourth the weight loss. Here is an excellent ablative covering with low thermal conductivity.

**The above chart shows** how the high thermal insulation of G-E silicone rubber is maintained during exposure to 9,000°F heat. It is also useful in mechanical and electrical applications at temperatures from —150°F to 600°F, where it remains resilient and flexible. It also maintains its excellent physical and electrical properties over this wide temperature range for extended periods.

**Continued high temperature testing** goes on at General Electric's Missile and Space Vehicle Department in Philadelphia. Shown above is a typical specimen undergoing plasma jet testing in an electric arc heated supersonic wind tunnel. Continuous testing like this will develop new data on the thermal and ablative uses of G-E silicone rubber.

**To learn more about G-E silicone rubber, and its uses as a thermal and ablative material, write: General Electric Company, Silicone Products Dept., Section I1161, Waterford, New York.**

**GENERAL ELECTRIC**



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SURVEY

**by V. A. Stanton,** Chief Metallurgist, National-Standard Co.*

# Super-alloys for high-temperature springs

FOR SPRING OPERATION at 400-1400 deg F, super-alloys are of prime importance. A great many of these alloys are available. A recent tabulation of 103 of them merely covered the most promising ones. *Table I* gives a further representative selection of these materials.

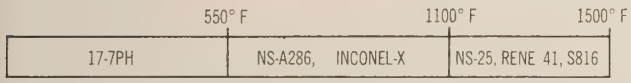
All the alloys in *Table I* are precipitation-hardenable in the 800-1500 deg F range and can be stress-relieved in the same range (and the same operation). The higher the temperature of the precipitation-hardening, the more stable generally will be the spring at high temperatures.

Ferritic alloys essentially are modified tool steels containing relatively small amounts of chromium, vanadium, and molybdenum. They are fairly cheap, but their low alloy content makes for poor corrosion resistance. The spring manufacturer's major concern it that he be able to form wire in a soft condition and then to quench and temper it to get maximum physical properties. This has proved possible with comparatively large ferritic springs and forms, but even so distortion problems and cost considerably limit the use of ferritic alloys.

Ferritic-austenitic 17-7PH has been widely used up to about 550 deg F and the newer PH15-7Mo has been used to a limited extent. NS-A286 austenitic alloy is one of the least expensive super-alloys. With its precipitation reaction at the high temperature of 1300-1400 deg F, it looks good for applications in which the costlier alloys are now used.

Inconel X is a very good alloy for which much spring data are available, including many relaxation test results for various stress levels and for wire in various conditions of stress relief. (A spring may be satisfactory with 15 per cent relaxation in one case and be limited to two per cent in another.) As more stability is needed,

* National-Standard Co., Niles, Mich.




**TENTATIVE** guide to alloy selection for high-temperature spring operation.

IN BRIEF

*Springs are key elements of many aerospace assemblies that must withstand temperatures up to 1800 deg F. Many of the materials that can be used for primary structures for these regimes are also good for springs, but obviously the design considerations aren't the same.*

*This survey reviews representative super-alloys that look good for spring operation at 400-1400 deg F. At least one of them has been used successfully up to 1800 deg F. Test data pointing to the application ranges of several of these alloys are given, and the effects of processing variables on performance are discussed. Generally, stability is more important for high-temperature spring materials than are maximum physical properties. As operating temperatures increase and stress correspondingly decreases, the wire tensile strength and other properties should be decreased for maximum stability.*

the stress must be lowered or a higher-grade alloy used. Before going to exotic and expensive materials, tests should be made to see if Inconel X will do the job.

René 41 is being checked for spring use at 1200 + deg F. Refractoloy 26 and Waspaloy are also being considered for high temperatures. Cobalt-base NS-25 and S-816 are being studied, and NS-25 is being used at 400-1400 deg F.

Super-alloys are melted in small heats of 100-200,000 lb. The type of melting depends on the alloying

**Table I: Compositions of Super-Alloy Spring Materials (per cent)**

| | Co | Cr | Ni | Mo | Fe | C | Al | Ti | Other |
|---|---|---|---|---|---|---|---|---|---|
| NS-1000 (ferritic) | | 4.75–5.25 | | 1.2–1.4 | bal. | 0.37 | | | 0.4–0.6V |
| 17-7PH (ferritic-austenitic) | | 16–18 | 6.5–7.5 | | bal. | 0.09[1] | 0.75–1.50 | | |
| PH15-7Mo (ferritic-austenitic) | | 14–16 | 6.5 7.5– | 2–3 | bal. | 0.09[1] | 0.75–1.50 | | |
| NS-A286 (austenitic) | | 13.5–16 | 24–27 | 1–1.75 | bal. | | | 1.75–2.25 | 0.35 Mg, 0.10–0.50V |
| Inconel-X (Ni-base) | 1[1] | 14–17 | 69[2] | | 5.9 | 0.08[1] | 0.4–1 | 2–2.5 | |
| Refractaloy 26 (Ni-Co alloy) | 20 | 18 | 38 | 3.2 | bal. | 0.03 | 0.2 | 2.6 | |
| Rene 41 (Ni-Co alloy) | 10–12 | 18–20 | 53 | 9–10.5 | 5.00 | 0.06–0.12 | 1.5–1.8 | 3–3.3 | 0.010B[1] |
| Wasp-aloy (Ni-Co alloy) | 13.5 | 19.5 | 56 | 4.25 | 1.00 | 0.05 | 1.3 | 3.00 | 0.005B, 0.062R |
| NS-25 (Co-base) | 50 | 19–21 | 9–11 | | 3[1] | 0.05–0.15 | | | 14–16W |
| S816 (Co-base) | 40–44 | 19–21 | 19–21 | 3.5–4.5 | 5.0[1] | 0.32–0.42 | | | 3–4.5Cb, 3.5–5W |

(1) Maximum. (2) Minimum.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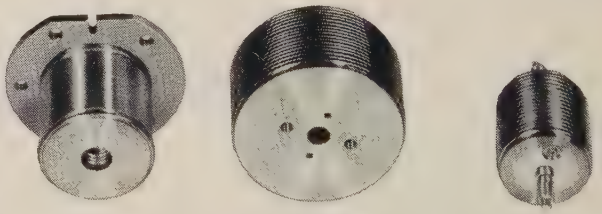

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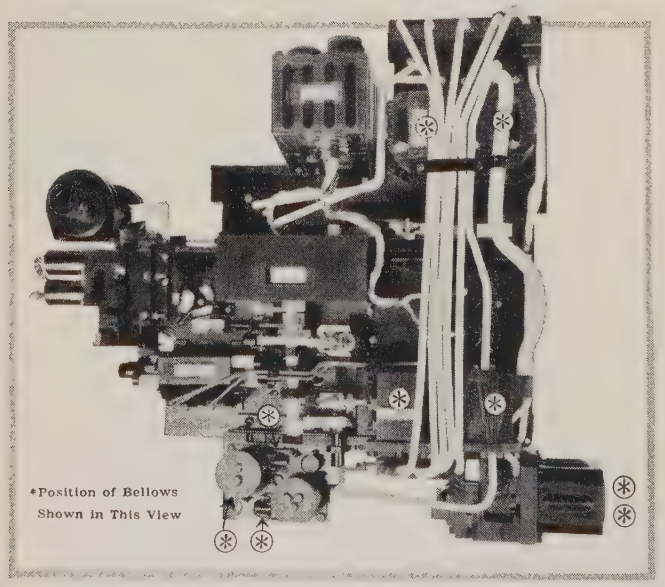


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**Table II: Suggested Treatment for Super-Alloy Spring Materials**

| Temper | Tensile Strength (psi)* As Drawn | Tensile Strength (psi)* After Hardening | Treatment |
|---|---|---|---|
| **17-7PH** | | | |
| Spring | 237,000 | 301,000 | 1 hr @ 900° F |
| 30% | 178,000 | 197,000 | " " |
| 15% | 152,300 | 148,000 | " " |
| **PH-15-7MO** | | | |
| Spring | 256,000 | 320,000 | 1 hr @ 900° F |
| 30% | 182,000 | 211,000 | " " |
| 15% | 146,500 | 152,000 | " " |
| **NS-A286** | | | |
| Spring | 184,000 | 236,000 | 16 hr @ 1350° F |
| 30% | 150,000 | 198,000 | " " |
| 15% | 122,000 | 190,000 | " " |
| Annealed | 105,000 | 176,000 | " " |
| **Inconel-X** | | | |
| 15% | 149,000 | 204,000 | 16 hr @ 13-1350° F |
| Annealed | 120,500 | 176,000 | 16 hr @ 1400° F |
| **Rene 41** | | | |
| 45% | 294,000 | 327,000 | 16 hr @ 1350° F |
| 30% | 272,000 | 298,000 | " " |
| 15% | 220,000 | 240,000 | 16 hr @ 1450° F |
| Annealed | 191,500 | 217,000 | " " |
| **NS-25** | | | |
| 30% | 207,000 | 205,000 | 16 hr @ 1300° F |
| 15% | 178,500 | 176,500 | " " |
| Annealed | 148,000 | 148,000 | 16 hr @ 1500° F |
| **S816** | | | |
| Spring | 274,000 | 329,000 | 16 hr @ 1300° F |
| 30% | 234,000 | 272,000 | " " |
| 15% | 183,000 | 198,000 | " " |
| Annealed | 151,000 | 154,000 | 16 hr @ 1500° F |

* For 0.080-in.-diameter wire.

elements. The only vacuum-melted alloys considered for spring wire to date have been materials like René 41 and Waspaloy.

After melting and rolling into hot rod, some alloys are drawn through one pass and centerless-ground. This grinding greatly increases the cost. It's sometimes needed, though, to get a surface of spring-wire quality. Whether a material has to be centerless-ground depends on the quality of the hot-rolled rod, the alloy's notch sensitivity or disposition to cracking during cold-drawing, and on the end use.

Centerless grinding presents another problem: The lengths that can be ground usually are 10-15 ft. To draw them down into finer wires requires many welds. Since welds aren't wanted in the finished spring, a magnetic material is used in the weldment. By checking all the springs with a magnet, springs containing a weld can be identified and discarded. If the material weren't welded, the finished coils would be so short that spring forming on an automatic coiler would be impractical.

For automatic coiling, superalloys are supplied as wire with a lime base coating. This lubricant can be left on the wire during stress relief without ill effects. If necessary it can be removed by a dip in 20 per cent nitric acid (by volume).

Since stress relief and precipitation-hardening are done above 1000 deg F, scale is often formed unless a protective gas atmosphere is used. Vapor-blasting will remove excessive scale.

In selecting a spring alloy for a given operating temperature, stress, time at temperature, required stability, cyclic conditions of stress and temperature, and environmental factors must be considered. The full-hard, or "spring" temper is not always best for stability in operation at over 500 deg F. Spring-temper materials are given their

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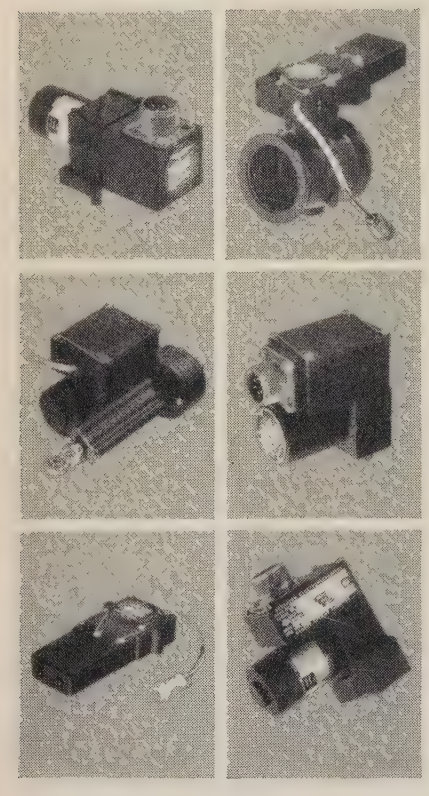

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high physical properties by cold-drawing and by precipitation-hardening after they have been formed into springs. For up to about 450 deg F, a material with the highest possible tensile strength is desirable. As the operating temperature increases and more stability is required, however, the design stresses for the spring must be decreased to prevent excessive relaxation.

Tests show that, as the final reduction in cross-sectional area decreases, the alloy becomes more stable at a given high temperature, providing the design stresses don't exceed the yield point. This criterion has been used with Inconel X for some time. In the No. 1 temper, Inconel X is more stable at high temperatures than is spring-temper Inconel X.

As the operating temperature increases and the stress correspondingly decreases, the wire tensile strength and other physical properties should be decreased for maximum stability. Depending on the operating temperature, a spring alloy should be tried in several different tempers:

- *300-600 deg F*—spring temper or 30 per cent;
- *600-900 deg F*—30 or 15 per cent;
- *over 90 deg F*—15 per cent or annealed.

*Table II* lists suggested stress-relief treatments. These generally give maximum precipitation-hardening and so optimum physical properties. They all call for holding at one temperature for a given time, and duplex heat treatments, which are under study, may prove superior to them.

As operating temperatures rise beyond 1000 deg F, consideration should be given to aging the material at temperatures higher than those providing maximum physical properties. Over-aging may produce greater stability ever though the physical properties are not optimum. If the aging treatments of *Table III* do not produce sufficient stability, a treatment at a level 100-200 deg F higher for the same length of time may be worth while. Tests at 650-1000 deg F have been run on 0.08-in.-diameter wire of several super alloys that was made into springs and stress-relieved. All wire was drawn in our Superalloy Pilot Lab, and complete records were kept on annealing conditions, die practices, and other processing variables. The stress relieving temperature was found for each alloy and temper by aging the wire 1-16 hours at 800-1900 deg F.

The wire was made into springs by various companies, stress-relieved and subjected to "nut-and-bolt"-type relaxation tests. The springs were compressed to a known load or stress and heated to a given tem-

**Table III: Stability of Super-Alloy Spring Materials***

| Temper | Treatment | Test Temp. (deg F.) | Load Loss (per cent) |
|---|---|---|---|
| **17-7PH** | | | |
| 30% | 1 hr @ 900° F | 650 | 4.1 |
| Spring | " " | 650 | 5.0 |
| 30% | 16 hr @ 900° F | 650 | 5.1 |
| Spring | " " | 650 | 6.2 |
| **PH15-7MO** | | | |
| 30% | 1 hr @ 900° F | 700 | 3.6 |
| Spring | " " | 700 | 7.2 |
| **NS-A286** | | | |
| Annealed | 16 hr @ 1350° F | 1000 | 3.0 |
| 15% | " " | 1000 | 7.1 |
| 30% | " " | 1000 | 16.9 |
| **Inconel-X** | | | |
| 15% | 16 hr @ 1350° F | 850 | 7.3 |
| **NS-25** | | | |
| 15% | 16 hr @ 1350° F | 850 | 6.1 |
| 30% | " " | 850 | 7.9 |

* Armco Steel data for 0.080 in.-diameter wire at 40,000 psi stress after 10 days at room temperature.

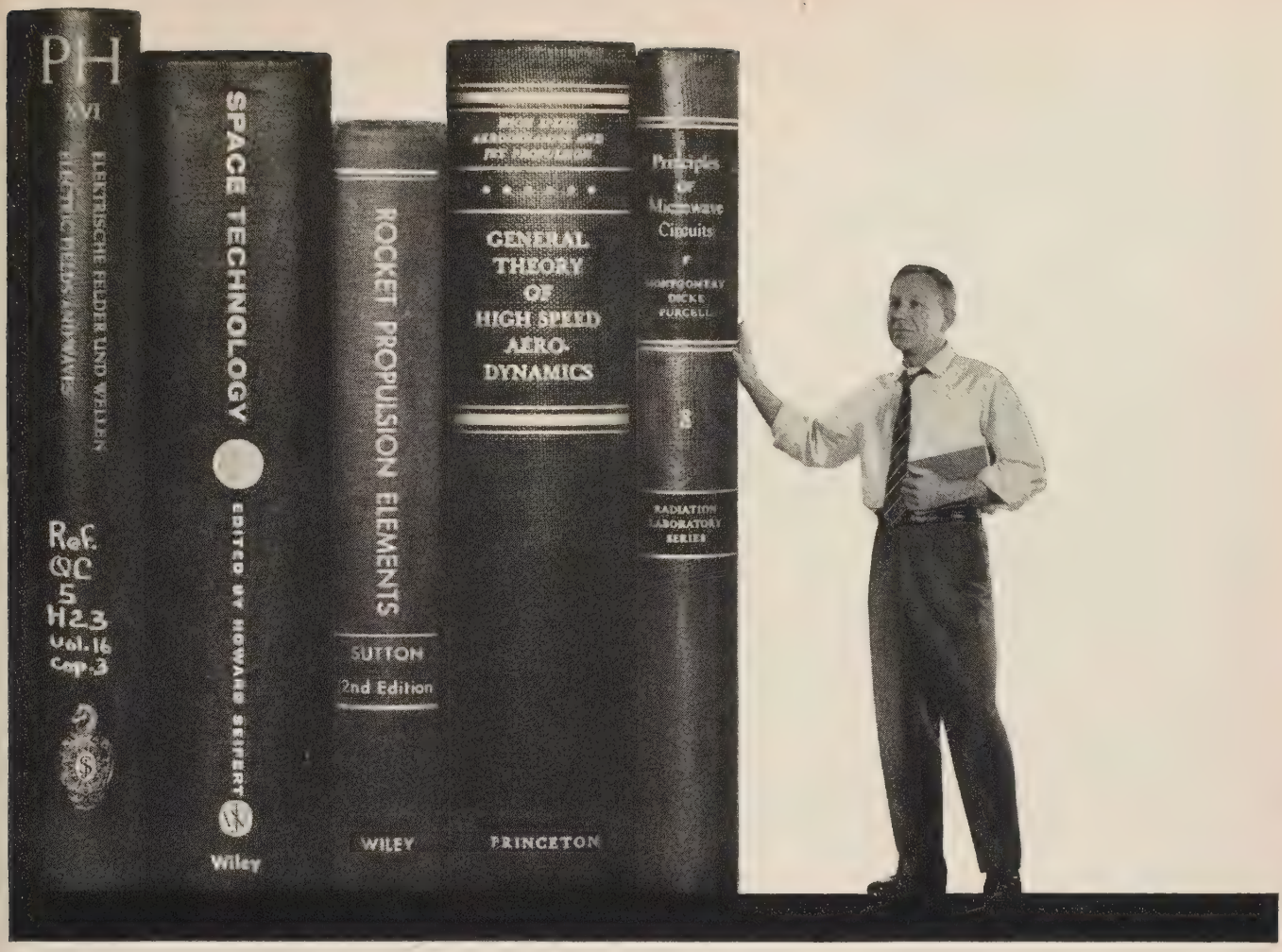


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**Table IV: Stability of Super-Alloy Spring Materials Tested at 600 deg F***

| Temper & Treatment | Stress (psi) | Load Loss (per cent) 5 Hr | 10 Hr | 20 Hr | 50 Hr | 100 Hr | 140 Hr |
|---|---|---|---|---|---|---|---|
| **17-7PH** | | | | | | | |
| Spring, 1 hr @ 900° F | 20,000 | 2 | 2 | 2 | 2 | 4 | 3.5 |
| | 40,000 | 2 | 2 | 2 | 2.5 | 2.8 | 3 |
| | 60,000 | 1.3 | 2 | 2.3 | 2.5 | 2.75 | 3.1 |
| | 80,000 | 1.1 | 1.4 | 2 | 3 | 3.1 | 3.4 |
| | 110,500 | 3 | 3.5 | 3.8 | 4.6 | 5.1 | 5.7 |
| Spring, 16 hr @ 900° F | 20,000 | 1 | 1.3 | 2 | 2.5 | 2.5 | 2.5 |
| | 40,000 | 1 | 1.5 | 2 | 2.6 | 2.6 | 2.75 |
| | 60,000 | 1.3 | 1.5 | 1.7 | 2.2 | 2.2 | 2.8 |
| | 80,000 | 1 | 1.4 | 1.6 | 2.2 | 2.7 | 3 |
| | 105,500 | 6 | 6.4 | 6.7 | 7 | 7.7 | 8 |
| 30%, 16 hr @ 900° F | 20,000 | 1.5 | 2 | 2 | 2.5 | 2.5 | 3 |
| | 40,000 | 1.5 | 1.6 | 2.2 | 2.9 | 3.2 | 3.6 |
| | 60,000 | 2 | 2.2 | 2.4 | 2.7 | 3 | 3.3 |
| | 80,000 | 2.6 | 2.6 | 2.8 | 3.6 | 5.1 | 5.5 |
| | 108,000 | 4.3 | 4.9 | 5.3 | 5.6 | 6 | 6.2 |
| 15%, 16 hr @ 1000° F | 20,000 | 1 | 1 | 1.5 | 2.5 | 2.5 | 2 |
| | 40,000 | 1.7 | 2 | 2.5 | 2.7 | 3 | 3 |
| | 60,000 | 3.7 | 4.3 | 4.9 | 5.2 | 5.8 | 6 |
| | 75,000 | 6.3 | 6.8 | 7.3 | 7.9 | 8.1 | 8.5 |
| | 89,000 | 5.8 | 6.3 | 6.8 | 7.5 | 7.7 | 7.8 |
| **PH15-7Mo** | | | | | | | |
| Spring, 16 hr @ 900° F | 20,000 | 1 | 1 | 1 | 1 | 1 | 1.5 |
| | 40,000 | 0.5 | 0.75 | 1 | 1 | 1 | 1.25 |
| | 60,000 | 0.5 | 0.75 | 1 | 1.3 | 1.6 | 1.75 |
| | 80,000 | 1.2 | 1.4 | 1.5 | 2 | 2.3 | 2.5 |
| | 111,500 | 1.6 | 2 | 2.5 | 2.6 | 3 | 3.1 |
| 30%, 16 hr @ 900° F | 20,000 | 1 | 1.0 | 1 | 1 | 1.5 | 1 |
| | 40,000 | 0.5 | 0.75 | 1 | 1.25 | 1.75 | |
| | 60,000 | 1.4 | 1.5 | 1.8 | 2 | 2 | 2.2 |
| | 75,000 | 2 | 2.5 | 2.7 | 2.8 | 3.1 | 2.9 |
| | 99,000 | 5.2 | 6.1 | 6.4 | 6.7 | 6.8 | 7 |
| **NS-25** | | | | | | | |
| 30%, 16 hr @ 900° F | 20,000 | 3 | 2.5 | | 2 | 2.5 | 2.5 |
| | 40,000 | 0.5 | 0.5 | 0.5 | 0.25 | 0.25 | 0.25 |
| | 60,000 | 1.1 | 1 | 1 | 1.2 | 1.3 | 1.3 |
| | 80,000 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| | 100,000 | 1.1 | 1.2 | 1.3 | 1.3 | 1.3 | 1.3 |
| | 118,500 | 4 | 4.1 | 4.3 | 4.9 | 5 | 5 |
| **Inconel-X** | | | | | | | |
| 15%, 16 hr @ 1350° F | 20,000 | 0.75 | 0.75 | | 0.5 | 0.75 | 0.75 |
| | 40,000 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | 60,000 | 0.25 | 0.75 | 0.75 | 0.75 | 0.9 | 1 |
| | 80,000 | 0.5 | 0.70 | 0.75 | 1 | 1 | 1.25 |
| | 107,000 | 0.5 | 0.70 | 1 | 1 | 1 | 1.1 |

* Bendix data for springs not heat-set.

perature for a specified time. Periodically, they were removed from the furnace and taken out of the jig to check changes in load or height. The summary of the test results in *Table III* shows that lowering the cross-sectional reduction increases stability under certain temperature-stress conditions.

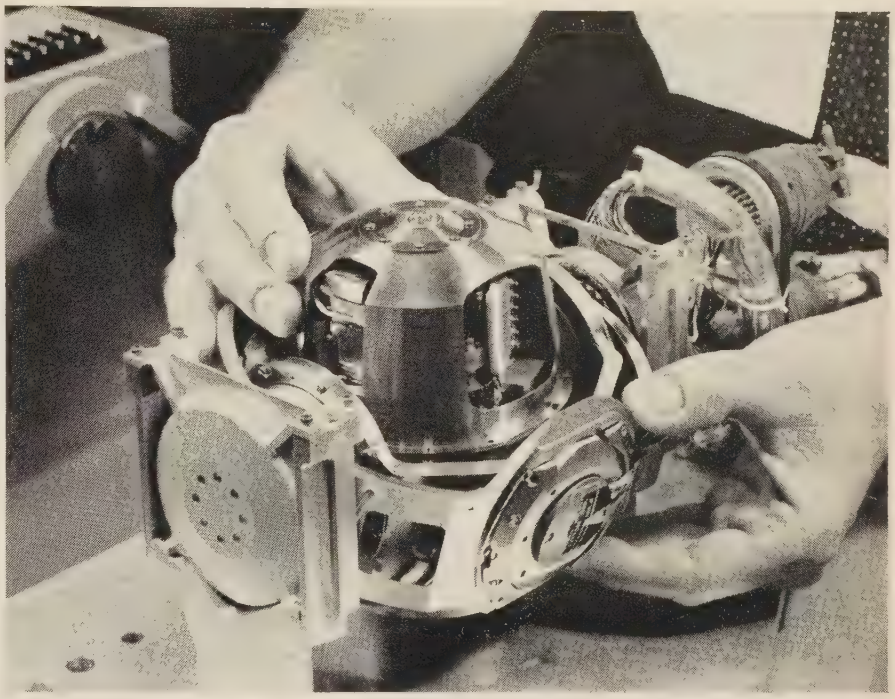
Particularly exhaustive tests of springs made under identical conditions were run at 600 and 1000 deg F (*Tables IV & V*). These These tests lasted long enough for the rate of relaxation to level off and indicate a stable condition.

Studies of the differences in temper and time of precipitation-hardening revealed by the tests led to these conclusions:

- The duration of stress relief at 900 deg F does not significantly affect the stability of 17-7PH. At 600 deg F, spring-temper 17-7PH is more stable at the higher stress levels than is lower-temper material. At stress levels up to 40,000 psi, the temper makes little, if any, difference.
- PH15-7Mo is superior to 17-7PH. At 650 deg F there's an appreciable advantage using the 30 per cent temper rather than the

# FROM SMALL TO SMALLER IN INERTIAL PLATFORMS

**Litton P-300 containing two new gyros, three improved accelerometers, four gimbals, and an advanced, irrotational vibration mount compacted into a 0.245-cubic foot, 15-pound unit for missile and space applications.**



The Litton P-300, a miniaturized inertial reference platform that rests comfortably in one's two hands, is the result of a program aimed at developing a small, light, reliable unit for orbital and suborbital vehicles. The challenge presented by the P-300 project at its outset was the formidable one of taking an already small production platform (the 30-pound Litton P-200) and chopping it in half without sacrificing performance.

As in the P-200, floated, two-degree-of-freedom gyros were selected to minimize the number of gyro rotor assemblies and to simplify the stabilization servo loops. The gyros were made smaller and their performance increased through the reduction of minor error torques, such as those from flex leads making electrical interconnection between float and case. The gyro wheel, float, and gimbal were constructed primarily of beryllium, greatly improving the stiffness-to-density ratio and reducing the mass shifts caused by anisoelasticity under acceleration. Despite the smaller size of the gyro rotor, high angular momentum was obtained by distributing the rotor mass in a manner that provides a large radius of gyration.

Gas-lubricated bearings are another and particularly noteworthy improvement in the small (2.1″ by 2.9″), light (under 2 pounds) gyros. These bearings use 1/20th of the clearance between bearing surfaces normally associated with oil-lubricated assemblies and offer other advantages that improve gyro performance by an order of magnitude.

The accelerometers in the P-300 were scaled down (to 0.8″ x 0.8″ x 1.5″) through similar imaginative engineering techniques without decreasing performance. Small and greatly improved, these accelerometers contain a sensitive element that is a floated pendulum mounted on a pair of jewel-and-pivot bearings and equipped with an electromagnetic pickoff and torquer. The relative motion of the pendulum is kept to a small fraction of a milliradian even at an acceleration of over 20 g.

Another feature of the P-300 is the use of direct drive gimbal torquing. By incorporating this type of torquing, the weight penalty paid in motors and gear trains has been greatly reduced. In addition, direct torquing significantly increases accuracy of the attitude readout.

*The P-300 inertial platform is the latest of more than half a dozen inertial navigation systems that have been successfully developed to the operational phase at Litton Systems. The Litton engineers who researched and developed these systems are always pleased to divulge additional details. Equally important, they are anxious to exchange ideas with new associates who have a sound flair for engineering of this sort. Write, phone or drop by for a visit. Mr. Don Krause, Litton Systems, Inc., Guidance & Control Systems Division, 5500 Canoga Avenue, Woodland Hills, California. Telephone DIamond 6-4040.*

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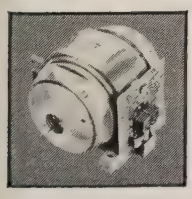

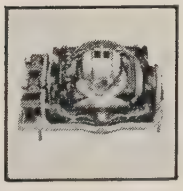

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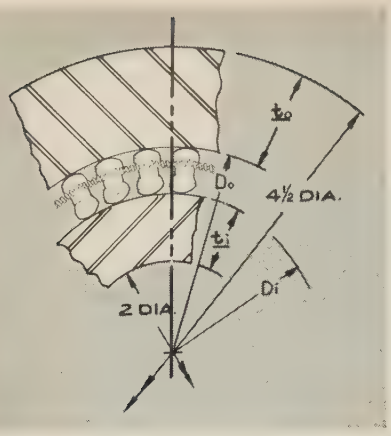


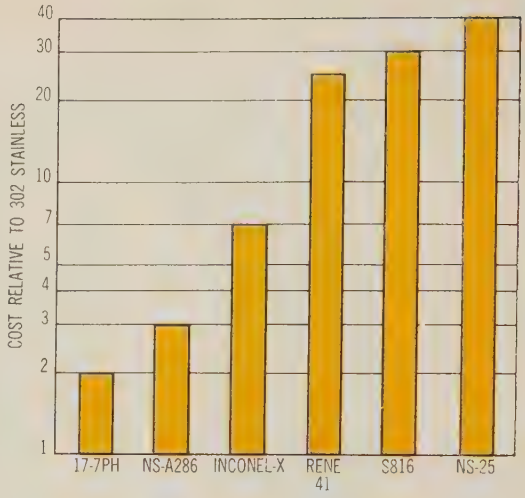


**COST** of super-alloy spring materials in comparison with 302 stainless steel.


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spring temper but at 600 deg F there is no such advantage.

- For operation at 1000 deg F, the annealed or the lowest-cold-worked condition is advisable.
- If a coating must be put on wire for automatic coiling, the cross-sectional reduction should be about 15 per cent (the maximum value for optimum stability).

**Table V: Stability of Super-Alloy Spring Materials Tested at 1000 Deg F[1]**

| Temper & Treatment | Stress (psi) | Load Loss (per cent) 5 Hr | 10 Hr | 20 Hr | 50 Hr | 100 Hr | 140 Hr |
|---|---|---|---|---|---|---|---|
| **NS-A286** | | | | | | | |
| 15%, 16 hr @ 1350° F | 10,000 | 5 | 5 | 5 | 5 | 5 | 5 |
| | 20,000 | 5 | 5.1 | 5.5 | 5.5 | 6 | 6 |
| | 40,000[2] | 5.8 | 6.3 | 6.4 | 6.8 | 7.5 | 7.5 |
| | 60,000 | 4.7 | 5.5 | 6 | 6.4 | 7.2 | 7.5 |
| | 80,000 | 6 | 6.8 | 8.2 | 9 | 10 | 10.3 |
| **Inconel-X** | | | | | | | |
| 15%, 16 hr @ 1350° F | 10,000 | 7 | 8 | 9 | 10 | 12 | 13 |
| | 20,000[2] | 7 | 8 | 10 | 13 | 14 | 15 |
| | 40,000 | 9.3 | 10.5 | 12.5 | 15.5 | 20 | 21.7 |
| | 60,000 | 8.3 | 10.5 | 13 | 17.3 | 19.8 | 21.6 |
| | 80,000 | 10 | 12 | 15.5 | 21 | 25 | 41 |
| **NS-25** | | | | | | | |
| 15%, 16 hr @ 1300° F | 10,000[2] | 6 | 7 | 9 | 11 | 15 | 17 |
| | 20,000 | 6.5 | 7 | 9 | 12.5 | 15 | 17.5 |
| | 40,000 | 6.8 | 7.75 | 9 | 12.5 | 15.8 | 18 |
| | 60,000 | 5 | 6.7 | 8.6 | 12.5 | 16 | 18.3 |
| | 80,000 | 5.4 | 7.3 | 9 6 | 13.5 | 18 | 20.8 |
| **Rene 41** | | | | | | | |
| Annealed, 16 hr @ 1350° F | 10,000 | 6 | 7 | 8 | 9 | 9 | 9.5 |
| | 20,000 | 6.5 | 6.5 | 8 | 9 | 10 | 10 |
| | 40,000 | 7.5 | 8 | 8.8 | 9.5 | 10.5 | 10.7 |
| | 60,000[2] | 6.3 | 6.7 | 7.7 | 8.6 | 9.3 | 9.3 |
| | 80,000 | 6.5 | 6.9 | 7.75 | 8.7 | 9.5 | 9.75 |
| 15%, 16 hr @ 1400° F | 10,000 | 10 | 11 | 12 | 14 | 15 | 15 |
| | 20,000[2] | 9.5 | 10 | 11.5 | 13.5 | 15 | 15 |
| | 40,000 | 10.5 | 11 | 12.5 | 14.7 | 15.7 | 16.5 |
| | 60,000 | 9.15 | 10.3 | 12.5 | 15 | 16.3 | 17 |
| | 80,000 | 8.3 | 9.3 | 11.5 | 14 | 15.6 | 16.8 |
| 30%, 16 hr @ 1400° F | 10,000[2] | 13 | 15 | 17 | 20 | 20 | 20 |
| | 20,000 | 12.5 | 14 | 17 | 19 | 21 | 23 |
| | 40,000 | 13.2 | 14.5 | 16.2 | 20 | 22 | 24 |
| | 60,000 | 11.6 | 13.8 | 16.6 | 19.3 | 21.7 | 23 |
| | 80,000 | 11.9 | 12.8 | 17 | 20.5 | 22.5 | 23.8 |

(1) Bendix data for springs not heat-set. (2) Maximum stress at which there was no significant relaxation after 20-50 hours.

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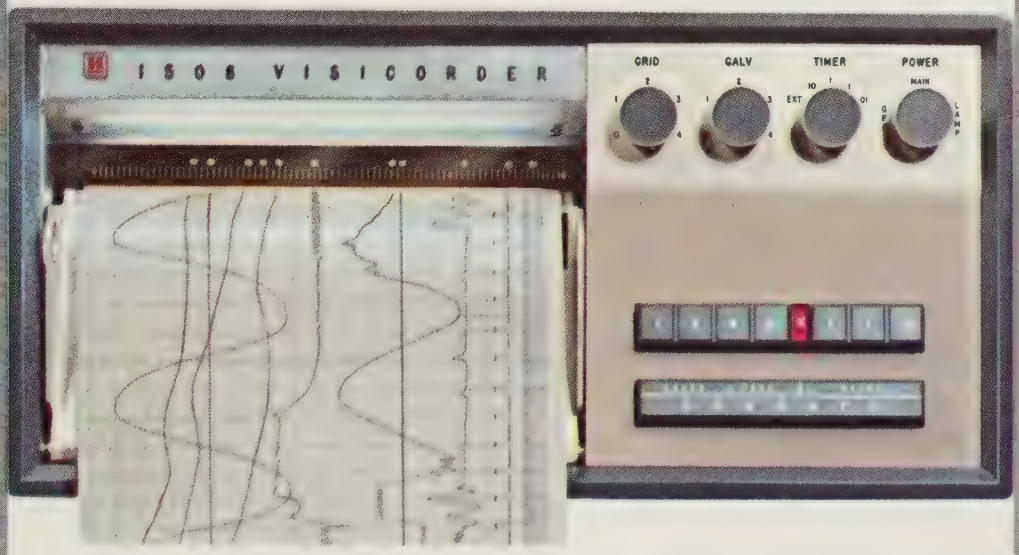
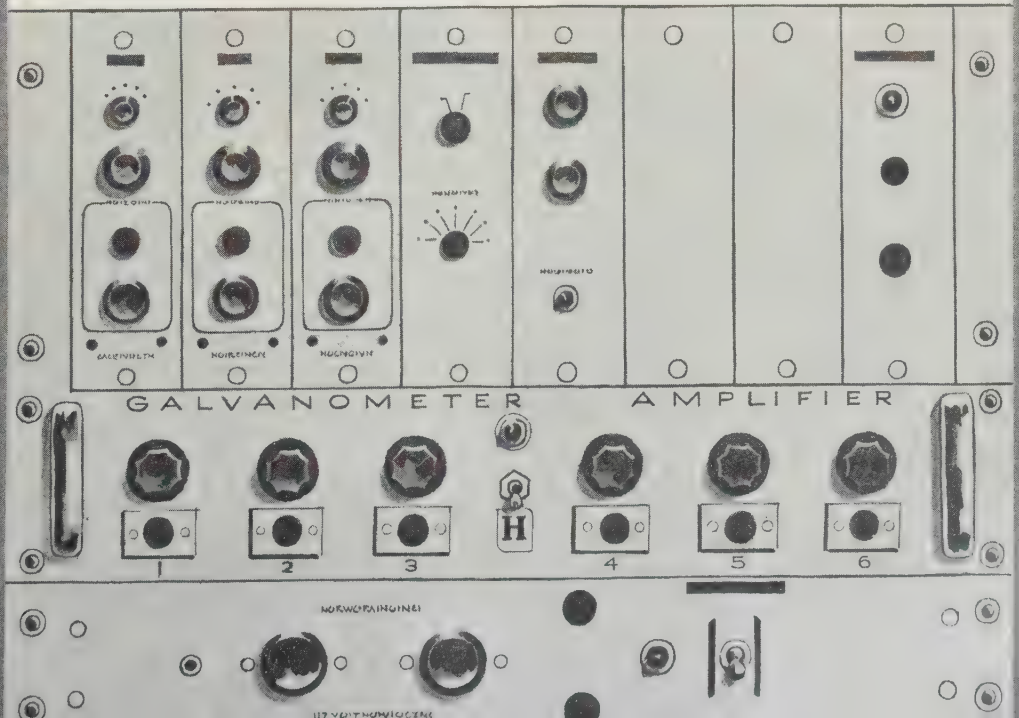
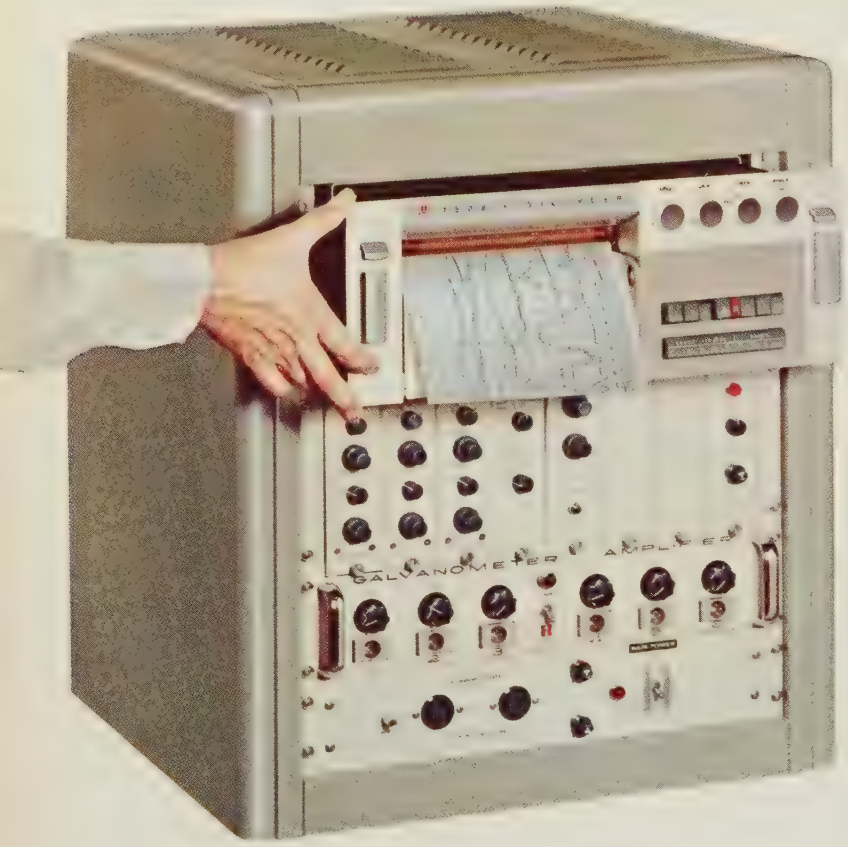
# Rack Mounted

## MODEL 1508 HONEYWELL VISICORDER OSCILLOGRAPH




Specifically designed to fit in only 7 inches of rack height, the Model 1508 Visicorder Oscillograph gives you a wider record, a greater record speed range, and more recording channels in less rack space than any other recording oscillograph.





# Features of the Model 1508 Visicorder Oscillograph

Using the famous Visicorder direct-recording principle that was pioneered, developed, and introduced by Honeywell, the New Model 1508 oscillograph records up to 24 channels of information simultaneously, producing immediately readable analog records without ink, styli, heat, powders, or chemical processing. Yet it is extremely compact—occupying only 7 inches of height in its rack-mount version—with many automatic features and the convenience of pushbutton controls. It is also available in a bench-mount model.

### *Maximum Operating Convenience*

The 1508 has been designed for easy operation and service. 12 record speeds—from 0.1″ through 80″/second— are push-button selected. All controls are handy on the front panel. You can load paper in seconds. In the rack model, the cover of the 1508 stays in the rack when the instrument is pulled forward, thus providing complete accessibility for service, lamp and galvanometer adjustment. As in all Honeywell Visicorders, the actual recording spots are visible at the point of recording for precise galvanometer calibration and monitoring of information.

### *Solid, One-Piece Magnesium Casting*

To prevent outside stresses on the instrument from introducing recording errors, the 1508 optical system, magnet assemblies, and drive system are mounted on a solid, one-piece magnesium casting.

These design refinements and extra quality features are typical of the superior instruments that have established Honeywell's leadership in the field of oscillography.

Ask your nearest Honeywell Field Engineer for a demonstration of the new 1508 Visicorder and other products described in these pages.

*The 1508 is available in two styles: one for rack-mounting (shown on opposite page), and one for bench-mounting (shown above).*

*The loading of recording paper into the 1508 is a simple process. The roll of paper drops easily into the receptacle with no need for threading.*

*All operating controls on the 1508 are located conveniently on the front panel.*

## *Condensed Specifications*
## *Model 1508*
## *Visicorder Oscillograph*

**CHANNELS:** 12 or 24

**GALVANOMETERS:** type M, sub-miniature.

**RECORD WIDTH:** 8″ (actual recording width 7⅜″) with provision for narrower widths.

**RECORD LENGTH:** 100′ standard, 150′ extra-thin, 200′ super-thin. Unused paper indicator.

**RECORD SPEEDS:** 12, push-button selected, as follows: 0.1, 0.2, 0.4, 0.8, 1.0, 2.0, 4.0, 8.0, 10, 20, 40, 80″/second, changeable during operation.

**FREQUENCIES:** DC to 5,000 cps.

**WRITING SPEEDS:** greatly in excess of 50,000″/second.

**TIME LINES:** 4-interval system with .01, 0.1, 1.0, and 10-sec. intervals. On-off switch; provision for external synchronization.

**GRID LINES:** 0.1″ with 5th line heavy, or 2mm with 1 cm heavy. On-off and density control. Special scales available.

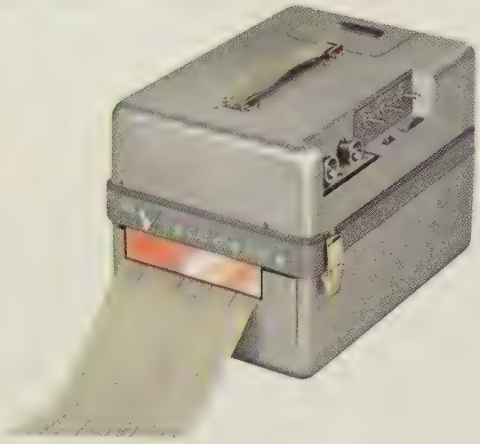
**OPTICAL ARM:** 11.8″ (30 cm) standard in all Honeywell Visicorders.

**TRACE IDENTIFIER:** 45° slope every 8″, spaced .032″ max., .02″ min.

**POWER:** 117v 60 cycle; 230v 50 cycle; 5-6 amps at 117v.

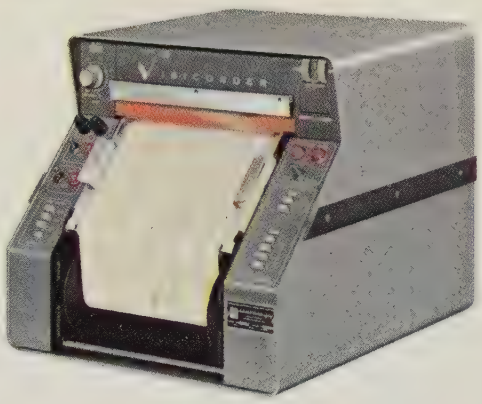
**DIMENSIONS:** 19″ wide x 7″ high x 17½″ deep excluding connectors and handles. Weight approximately 50 lb.

## Other Models of Honeywell Visicorder Oscillographs

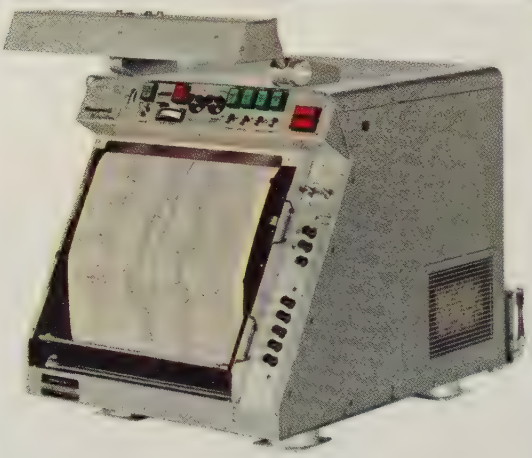


**MODEL 1406**...An efficient, dependable direct-recording oscillograph which makes the Visicorder principle available, on an extremely low-cost per channel basis, to users with recording requirements in the middle frequency range. Records up to 6 channels with special Type L Honeywell galvanometers.

**MODEL 906C** . . . with 8- or 14-channel capacity, built-in grid line and timing system, and self-starting lamp for remote operation. The built-in flash-tube timing system may be used normally or triggered externally.



**MODEL 1108** . . . an intermediate 24-channel instrument which fits logically between the 14-channel 906C models and the 36-channel model 1012. The 1108 has such extra features as automatic record length control, record reverse, record numbering, push-button record speeds and time-line intervals, and integral record take-up.



**MODEL 1012** . . . the ideal instrument for large-scale uses, the 1012 is the most convenient and versatile oscillograph ever built for directly recording as many as 36 channels of dynamic data. It includes all the automatic features of the Model 1108 and more besides.

### USES OF THE VISICORDER

Visicorder Oscillographs are useful as direct readout units in systems for either RECORDING or MONITORING of almost any type . . . in CONTROL applications to monitor reference and error signals . . . in MISSILE and ENGINE ANALYSIS for test stand recording . . . for analog recording of TELEMETERED SIGNALS . . . in NUCLEAR TESTING to record temperatures, pressures, impacts . . . in LABORATORY work for all-purpose analyses . . . in PRODUCTION for final dynamic inspection . . . in COMPUTING for immediately-readable analog records . . . in PILOT TEST for rapid examination of prototypes . . . in ALL TESTS which are non-repetitive in sequence where oscilloscopes are impractical.

Write for further details on the new Model 1508 Visicorder Oscillograph, or call us at SKyline 6-3681, Direct Distance Dialing Code 303
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NOVEMBER 1961

# aerospace electronics

Launch position fixing system for road-mobile ballistic missiles, designed by Kearfott as combination of odometer wheel (for distance measurement) and the company's S-121 inertial platform (for azimuth reference), mounted in a truck for tests at Chrysler.

lo. 140
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*Sensors, Gyros, Actuators, Computers for Future Spacecraft*

A JPL survey of spacecraft guidance and attitude control requirements over the next four years shows that we will need sensor accuracies as high as 0.001 deg. It's unlikely that spacecraft will be controlled in attitude to better than 0.05 deg, but higher accuracies are needed in guidance sensor subsystems like gimbaled star and planet seekers and trackers that can be independent of the exact vehicle orientation.

According to JPL, no breakthroughs are needed to attain the sensor performance required through '65. In fact, some existing sensors already meet the requirements. The problem is how to build accurate sensors that will perform under the rigors of space flight.

| Sensor | Measurement | Year | Performance |
|---|---|---|---|
| Sun sensor | angular deviation from line toward center of sun | '62<br>'64 | 0.01 deg<br>0.001 deg |
| Planet sensor for altitude control | angular deviation from center of radiation of planet | '62 | 0.01 deg |
| Planet sensor for guidance | angular diameter & deviation from true center of planet (long range) | '62<br>'64-'65 | 0.01 deg<br>0.001 deg |
| Horizon scanner | | '64<br>'62<br>'64-'65 | 0.1 deg<br>0.01 deg<br>0.001 deg |
| Star sensor | angular deviation from star | '62 | 0.01 deg |
| Gyroscope | commanded turns of spacecraft away from celestial references (short term); angular rates of turn | '64-'65<br>'64-'65 | 0.001 deg<br>0.001 deg/hr |

For stellar identification, the storage of star maps or catalogs to be compared with observed star patterns causes unnecessary complications, JPL believes. A much simpler method, it says, is to acquire the sun first and then identify just one star. This would be enough for a complete coordinate reference system.

**Stability as Gyro Criterion** For the typical gyro in the spacecraft of the near future, stability will be a major criterion. As acceleration effects will be minimal during normal space flight, JPL regards restraint and reaction torques as the main source of gyro error. It believes gyro designers should pay more attention to these torques and their variations in stability.

Pulse-torquing of inertial instruments looks good to JPL's guidance engineers because of its compatibility with digital computation and operation. They would like to see more industry work on simpler pulse-torquing circuits.

**Gyro Performance**

| | Present | '62 | '64 |
|---|---|---|---|
| Mass imbalance (deg/hr/g) | 0.2 | 0.1 | 0.05 |
| Mass stability (deg/hr/g) | 0.05-0.2 | 0.1 | 0.05 |
| Reaction torques (deg/hr) | 0.7 | 0.2 | 0.1 |
| Reaction stability (deg/hr) | 0.2-0.5 | 0.05 | 0.01 |
| Restraint torques (deg/hr/mr) | 0.05-0.1 | 0.05 | 0.01 |
| Restraint stability | 0.05-0.1 | 0.05 | 0.01 |

Electrostatic and cryogenic digital-readout gyros look promising for meeting the 0.005-deg/hr requirement predicted for '65, JPL says. When electric propulsion becomes feasible, we will need acceleration sensors with a dynamic range of at least $10^5$ and a lower limit of repeatibility around $3\times10^{-9}$ g, it is stated.

**Actuation beyond '64** Among actuation devices, JPL foresees cold-gas, hot-gas, and vapor-pressure mass expulsion systems as well as reaction wheels and spheres within the next three years, and solar-pressure systems (near the earth's orbit) for the period beginning in '64. An on-off cold-gas mass expulsion system will be used in JPL's Ranger. One of the prime requirements of this kind of system is linear or semi-linear flow control valves with a leakage no less than five $cm^3$/hr in the "off" position and a flow linearity of 20 per cent or better.

Hot-gas pulse systems with an impulse per actuation of 0.005-0.01 lb-sec and an integrated thrust of 0.5-1 lb will prove attractive, says JPL, if they can be made reliable enough. For use by about '65, JPL foresees a throttleable system with a thrust range of 0.01-1 lb and a minimum burning time of one second.

Other requirements predicted by JPL are:

- Simple, reliable, and small digital angular pickoffs with accuracies of 20-30 seconds of arc over 360 deg will be needed over the next few years. Later on, the accuracy requirement will go up to 2-5 seconds of arc.
- The actuation devices needed between now and '65 for articulated assemblies will have to have output torques of 5-10 ft-lb and output rates of 1-5 rph. Such a unit should weigh 2-5 lb, its power input during actuation should be 1-3 W, and a simple stepping action should be used at the actuation method.
- Three types of digital computers will be needed for the spacecraft of the next decade: (1) a navigation computer that can perform relatively lengthy computations at moderate computing speeds and that probably should have a 100,000-bit magnetic drum; (2) a computer for storage and processing of scientific data, operating at megacycle rates and with a storage capacity of at least a million bits and of 10 million bits before '70; (3) a high-speed computer with both sequential- and random-access memories for control of the spacecraft and its experiments.
- Magnetic-drum memories holding 100,000 bits that have a steady-state power drain of less than five watts and use mechanical parts will be needed for 99 per cent error-free operation over a one-year period in a vacuum greater than $10^{-8}$ mm Hg.

All-magnetic circuits look promising for spacecraft computers, according to JPL, and would look even better if their power drain could be cut. One of the main advantages of magnetic elements, JPL points out, is that they probably will stand up better under nuclear radiation than semiconductors.

**Ogo Stabilization** A reaction wheel will be used with a bang-bang controller for the first time in the attitude stabilization system of STL's Ogo satellite. The

# INTELLIGENCE

system is in the breadboard phase and is working out quite well, according to STL.

A magnetic amplifier—made feasible for the system's low-frequency response—will be used in place of transistors in the system's preamp (a DC amplifier). STL studies showed that the magamp has a failure rate of 400 per $10^9$ hours, while the group of transistors needed to do the same job would have had a failure rate of 600-1600 per $10^9$ hours.

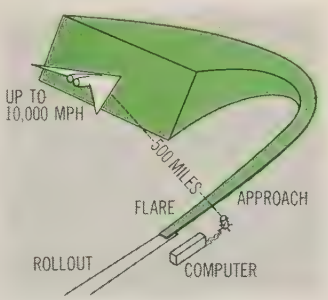
**Reliability Goal for Space** For the near future, the reliability requirement for spacecraft electronics is on the order of 10,000 hours of continuous operation without failure, a leading Aerospace Corp. engineer told SPACE/AERONAUTICS. The best we can do now, he says, is about 1000 hours between failures—provided we carefully select the parts, derate, artificially create a relatively mild environment, and control the energy stress levels.

We can get from where we are now to the 10,000-hour goal, the Aerospace engineer stated, in two steps:

- Make a parts development program mandatory for all future systems.
- Use well-thought-out part, circuit, and function redundancy.

The Aerospace engineer claimed that we still have no overall reliability concepts. Present parts-improvement programs like those for Minuteman and Nike-Zeus, he pointed out, are tied to specific missions. You cannot directly extrapolate from the data from one specific program for the benefit of another where energy stress levels are different, he asserted. The Minuteman and Zeus component development programs, he says, are advancing the state of the art only to the extent that the participants learn more about parts and about managing a parts-improvement program. They are not giving the industry either a group of broadly applicable reliable parts or broad reliability concepts.

**Re-Entry Landing System** An automatic landing system for unpowered re-entering spacecraft and re-usable boosters is under development at GE's Defense Systems Division. It uses radio command guidance to solve the problems of energy management after re-entry.




The vehicle is first acquired by radar at 500 miles. Then a safe path is calculated to avoid overheating and overstressing, and finally the vehicle is guided through the approach, flare-out, and landing roll. Under normal wind conditions and for a landing speed of 100 fps, the sinking speed during flare and landing would be controlled with 1-2 fps.

The ground equipment includes GE's AN/TPQ-10 radar and 225 digital computer. A 12-lb tracking beacon, an 11-lb decoder, and a five-pound antenna would be carried aboard the vehicle. GE has already simulated over a hundred landings on an analog computer, using various system configurations. Raytheon is working on a system performing a similar function but based on a different design approach.

**ATC Control Technique** An electronic handoff system for ATC is being studied by Martin under a $17,000 contract from FAA. Martin will try to find out how to design an automatic control technique for transferring aircraft in flight from the control of an air traffic center to an airport control tower.

**DME Praised** American Airlines has announced it is well pleased with ITT's DME, which it has been using since '59 in its Boeing 707, and now flies some 9500 hours a month. American is the only airline whose entire fleet uses DME. FAA has set up a mandatory program for installing DME on commercial planes, which by July 1, '64, will cover all planes with a takeoff weight of more than 12,000 lb.

An L-band, pulse-modulated transponder, DME is probably the most complex electronic gear in airline service today. American says it has had an MTBF of 4.75 per 1000 hours on its DME's, which it would like to lower to around 3 per 1000 hours. (The MTBF for American's VOR receivers is 2 per 1000 hours.)

## *Plans for Syncom, Relay II and Advent Communications Satellites*

Syncom represents a "quick and dirty" approach to getting operating data on a 24-hour-orbit communications satellite, Daniel G. Mazur, Chief of Systems & Projects at NASA's Goddard Space Flight Center, revealed at last month's ARS meeting in New York City. To be built by Hughes Aircraft, Syncom will be put into an orbit inclined 33 deg to the equator at 24,300 miles altitude. It will describe a figure-eight pattern over a longitude over the Atlantic between 33 deg N and S. A narrow band system (30-50 kc), it will radiate about two watts in the two-kmc region. The modulation will be FM/FM, and the ground transmitter will work in the eight-kilomegacycle band.

Syncom will be spin stabilized and have simple gas-jet period and attitude control. Its orbit will be controlled from the ground on the basis of range and range-rate information transmitted by a beacon in the satellite.

**Relay II Prospects** Mazur hinted at a new NASA communications satellite program when he stated that "early consideration should be given to the investigation of the six-hour sub synchronous orbit—either circular or elliptical—at inclinations of 60 or 63.4 deg. It is within our present capability to attain such orbits using the Atlas-Agena B . . . , carry[ing] sufficient weight to provide four wide-band transponders suitable for either TV or multiplex telephony. Interim service to the major centers of communication could be furnished by a system of this type, asuming adequate power, a simple

**An easy "push" to connect and "pull" to disconnect** is all it takes to operate the new Deutsch high-pressure fluid and gas coupling. No twisting or tricky lock movements are necessary. Here then is an effective design that can be specified for a variety of remote, umbilical, modular, or rack-and-panel applications. Safety at high operating pressures is assured by a color ring that provides visual inspection for positive lock.

And both coupling halves exceed all requirements of MIL C-25427 for fluid loss, pressure loss, air inclusion, and physical shock. Temperature range is −200°F to +450°F.

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No. 38 on Reader Service Card

orientation and period control device, and addition of antenna gain capability."

The subsynchronous satellite to which Mazur referred is known within NASA as Relay II but has never been announced publicly. NASA engineers unofficially have told SPACE/AERONAUTICS that they expect to let a contract for this system either late this year or early next year.

In addition to reliability, what communications satellites need most urgently, Mazur said, is an attitude control system or antenna that automatically "homes in" on ground signals.

Telstar is the new name of AT&T's experimental commercial communications satellite, formerly code-named TSX, Mazur announced. Several engineers in the audience questioned the need for both the Relay and Telstar programs, since they are so similar in design. They also questioned the usefulenss of NASA's projected experiments with low-orbit communications satellites when it has already been admitted that in the end a 24-hour satellite will be used.

**Advent Details** The outlook for the Advent, an equatorial-orbit satellite, was reviewed at the ARS convention in a paper by Ralph Clark, of DOD. Clark noted that one of the early design figures for the satellite had called for a payload of 1272 lb, but that this weight has since been cut to "1000 lb plus." Next summer, he reported, Atlas-Agena-Bs will boost attitude-controlled Advent test vehicles into intermediate-altitude, inclined orbits. From an equatorial launch site, Clark stated, about 420 lb more payload could be orbited than from Cape Canaveral, Fla. At present, he said, this is not enough extra weight to justify the expense and logistics problems of an equatorial launch site.

Other Advent details had been given earlier at a local IRE meeting by Peter Moresco, of the Army Signal Corps' Electronics Lab:

- The payload will be completely transistorized save for three electron tubes to handle a few watts of RF.
- The satellite will use two antennas for duplex operation.
- Two banks of 3500 solar cells each will supply electric power.
- Final corrections in the satellite's position in space will be made a hot-gas hydrazine-mix control system. Once the correct orbital position, velocity, and path have been established, the satellite's attitude will be maintained by a pair of IR horizon seekers on mutually perpendicular axes and a cold-gas activation system.
- The satellite will have a temperature control system consisting of vanes that open and close to keep the internal temperature at 50-75 deg F by adjusting the heat dissipation characteristics of the exterior surface.
- The ground stations will use 60-ft-diameter antennas (paraboloids mounted on reinforced concrete pedestals). If they meet the specs, these will be the most accurate tracking antennas ever built in the U.S. Tracking will be automatic.
- The power gains of the ground tracking antennas will be 50-60 db.
- Shipboard tracking stations will have a 30-ft antenna dish completely enclosed in a spherical radome.

**Advent Schedule**

**Early '62:** *Eight Atlas-Agena-B shots to check electric power, attitude control, TT&C, orbital control, environmental sensors, communications in six-hour circular orbit at 5600 nm*

**Late '62:** *Two Atlas-Centaur shots to check attitude and orbital control, TT&C, electric power, microwave communications, temperature control, environmental sensors in 24-hour equatorial orbit (circular at 19,300 miles)*

**'63:** *Two Atlas-Centaur shots to check overall system operation in 24-hour equatorial orbit*

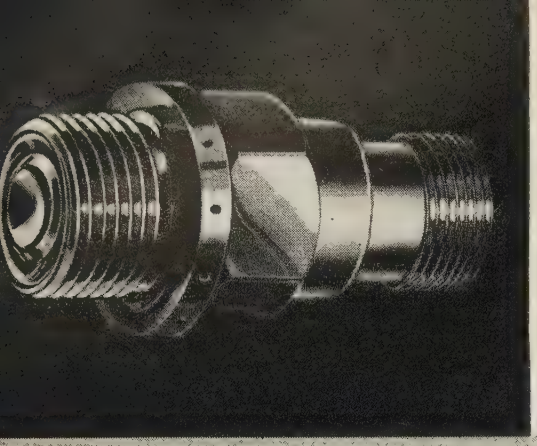
**GE on Diodes** GE entered the semiconductor diode market with an announcement by its Electronic Components Div. that it had added signal diodes to its semiconductor line of transistors, rectifiers, and tunnel diodes. It is starting with a general-purpose, planar, epitaxial, passivated silicon diode for high-speed switching.

GE also used the occasion to reaffirm its confidence in the tunnel diode. It estimated that the "use of tunnel diodes will increase from today's million or so units to well over 100 million units by '65."

**"Codiphase" Radar** A coherent digital phased-array system is being worked on by Sylvania as part of the ARPA's Defender ballistic missile defense research program. Sylvania's "Codiphase" includes a novel phased-array radar antenna and signal-processing and beam-forming techniques. According to the company, Codiphase can concurrently search for and track many targets, is immune to confusion devices, and costs less and is more flexible than present phased-array systems.

**"Seeding" the Ionosphere** A highly imaginative plan to inject chemicals into the ionosphere to extend its reflectivity region to 200 mc, is being worked on by Sperry Gyroscope. Small rockets would be launched into the ionosphere to discharge chemical powders like cesium. The chemical would then be "fertilized" by RF-energy bombardment with frequency-controlled, high-intensity microwave beams radiated from a ground station. The impinging radio beams would sustain the ionization of the chemical cloud.

Sperry believes that a single application of the chemical-microwave-energy combination would produce a VHF signal reflector in the ionosphere for a period of several hours. After that, the chemicals would dissolve harmlessly and have no further effect on RF transmissions.



NORWOOD CONTROLS

# BONDED STRAIN GAGE PRESSURE TRANSDUCERS

...for static and dynamic pressure measurement

## UNEXCELLED FREQUENCY RESPONSE

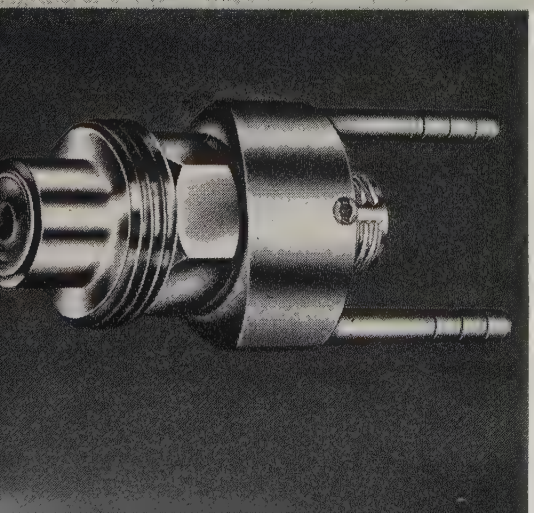
Exceedingly high frequency response characteristics (flat within ± 1 db from DC to 20,000 cps) result from the small mass and minute deflection of the assembly consisting of pressure sensitive diaphragm and strain tube with bonded strain gages. Models covering entire pressure range—0 to 60,000 psi—are virtually unaffected by extreme vibration or acceleration.

## BUILT-IN PRECISION

Unique Norwood design offers repeatability better than 0.1%, linearity is ± 0.5% of full scale. Transducers are available in a variety of two and four arm bridge designs, including models with provision for external shunt calibration. Bonded strain gage design means low maintenance and high reliability.

## AIR OR WATER COOLING

Models are available uncooled or for either air or water cooling. With air cooling gas temperatures as high as 2000°F can be applied safely. Water cooled models can measure gas pressures at temperatures to 5000°F, liquids to 1000°F.



**Complete Norwood line is described in Bulletin 278. Write American-Standard Controls Division, 5900 Trumbull Avenue, Detroit 8, Michigan today for your copy.**

AMERICAN-Standard PRODUCTS

AMERICAN-Standard

CONTROLS DIVISION

No. 39 on Reader Service Card

**Aerospace electronics** appears to be at a crossroads: The government is spending much more money on it than ever before (though it's getting less per dollar), yet there are by now so many manufacturers and labs in the field that there's not enough work to go around. Most of the dollars are being concentrated on a relatively few programs (e.g., Apollo, Zeus, Polaris, Advent).

The military long ago ceded its technical planning role to the industry and is now trying to get it back. A force of nomadic electronics engineers roams the industry from job to job, contributing little to the overall effort but profiting handsomely in personal status and pay.

Companies have gotten into electronics that never were in it before. Some have made surprisingly valuable contributions. Most have contributed nothing of substance.

Industry observers await the shakeout, some anxiously. The violent semiconductor price war, which has already killed off several manufacturers, they see as the first sign.

The receiving-tube industry has felt the predicted impact of the transistor and the solid-state diode. Some of the industry's largest tube assembly lines have slowed down or stopped completely. Even in special-purpose applications the electron tube is losing ground.

The challenge of space has been thrust upon the electronics industry long before it has solved its many mundane problems of missile guidance, defense against missiles, ground and airborne radars, tracking and communications, air defense, automatic landing, ATC, and collision avoidance.

Overriding all other troubles and cutting across all facets of aerospace electronics, is the problem of unreliability in severe environments. For all the fine writing and talking about reliability, at least half of the manufacturers in aerospace electronics are merely paying lip service to reliability while they try to push their products out the door. Almost all companies have reliability groups—because the customer insists on them. Few of these groups have the authority to countermand a design, to insist upon certain practices, or to do more than recommend components. Many design groups apparently are awaiting for the arrival of the thin-film, solid-state, and molecular circuits when we can retire the word unreliability (and most of the reliability engineers). Even if, day after tomorrow, these developments fulfill the glowing predictions made for them, what about today's systems and tomorrow's?

A two-part solution has been proposed to insure reliability in the near future:

- Use only parts with a proven history of reliability.
- Use "judicious" redundancy.

As we appear to be in the asymptotic region of the reliability-gains-with-parts-improvement curve, this is not likely to be the whole answer, but it may have to do until we solve the riddle of failure mechanisms.

One thing is certain: Unreliability will be far more catastrophic in spacecraft than it has ever been before. The cost per launch is just too great for payload failures that cause aborts or impair the mission.

The industry has great plans for long-lived, complex spacecraft, but it has litle hardware proof that these plans are feasible. As yet we cannot put a vehicle into a circular orbit. We've never had an attitude stabilization system that worked for more than a few days. We've never even had any satellite electronics, save the very simplest, that lasted more than a few months. Yet we glibly base our calculations on circular orbits, talk about year-long stabilization, and 5-10-year lifetimes for electronic payload.

Communications has explosively come to the fore. After decades of negligence we've suddenly realized that we are generating far more essential information than we can transmit.

The strategic bomber and the ballistic missile demand global communications that outstrip our present systems. HF is still too undependable (even SSB-HF), "tropo" stations have to be too closely spaced, "iono" systems don't have the bandwidth, and cables are too vulnerable.

Satellites seem to be the answer—for both military and commercial communications. New transmission methods are being proposed and worked on that cover the entire spectrum form VLF to ultraviolet and range from earth-strata and undersea cable systems to space networks. New methods of modulation and signal processing and the use of information theory already are providing greatly improved systems. But it seems as though we have only scratched the surface of the problem. It doesn't take a crystal ball to see that communications, data processing (the two are inextricably related), data gathering systems (e.g., radar, IR optics), computation, and control have an assured future in space. Energy conversion, electric power transmission, and electric-electronic propulsion also present fertile ground for the talents of aerospace electronics companies.

Much of the future of electronics in space, however, depends on developments in propulsion. Once we've overcome the current propulsive limitations we'll be able to put men into space, carry more of a payload, and probe deeper into the cosmos. Any of these achievements would mean great new opportunities for electronics, technically as well as economically.

**About six years ago,** an ITT engineer said that "the airline navigator dreams of the day when there will be no more charts, hand calculators, parallel rules, etc., and he can solve his problems automatically. The airline operator dreams of the day when there will be no more navigators." It looks as though the operator's dream is about to be fulfilled. First the overseas airlines installed Loran equipment that could be operated from the cockpit. Now it's Doppler radar. FAA recently approved "in principle" the use of Doppler in conjunction with other navaids for overseas flights. Since the Doppler can be worked from the cockpit by the copilot, it puts the navigator's job in jeopardy. TWA's navigators are already claiming that their company is unwilling to negotiate a new contract mainly because of Doppler radar.

MARQUARDT INTRODUCES...

# TM-6 THE ONLY UNIVERSAL TESTING MACHINE THAT LIVES UP TO THE NAME

Now you need only one machine to answer the full range of current or projected testing requirements. With this truly universal automatic test machine you can accurately perform tension or compression tests at uniform strain or load rates, and bending, creep, creep-relaxation, recovery, fatigue, cycling, hysteresis, shock, time delay to yield tests, or any test requiring the application of a precisely known and controlled force or true strain on *any material.* ■ Heart of the TM-6 is a closed loop, high response, servo-controlled, hydraulic loading system and is available in ranges of 42 grams to 15,000 lb., 25,000 lb., or 50,000 lb., with a hydraulic power stroke of 12 inches. Completely automatic operation over extremely wide ranges is achieved by advanced design emphasizing ease of operation, reliability, accuracy.

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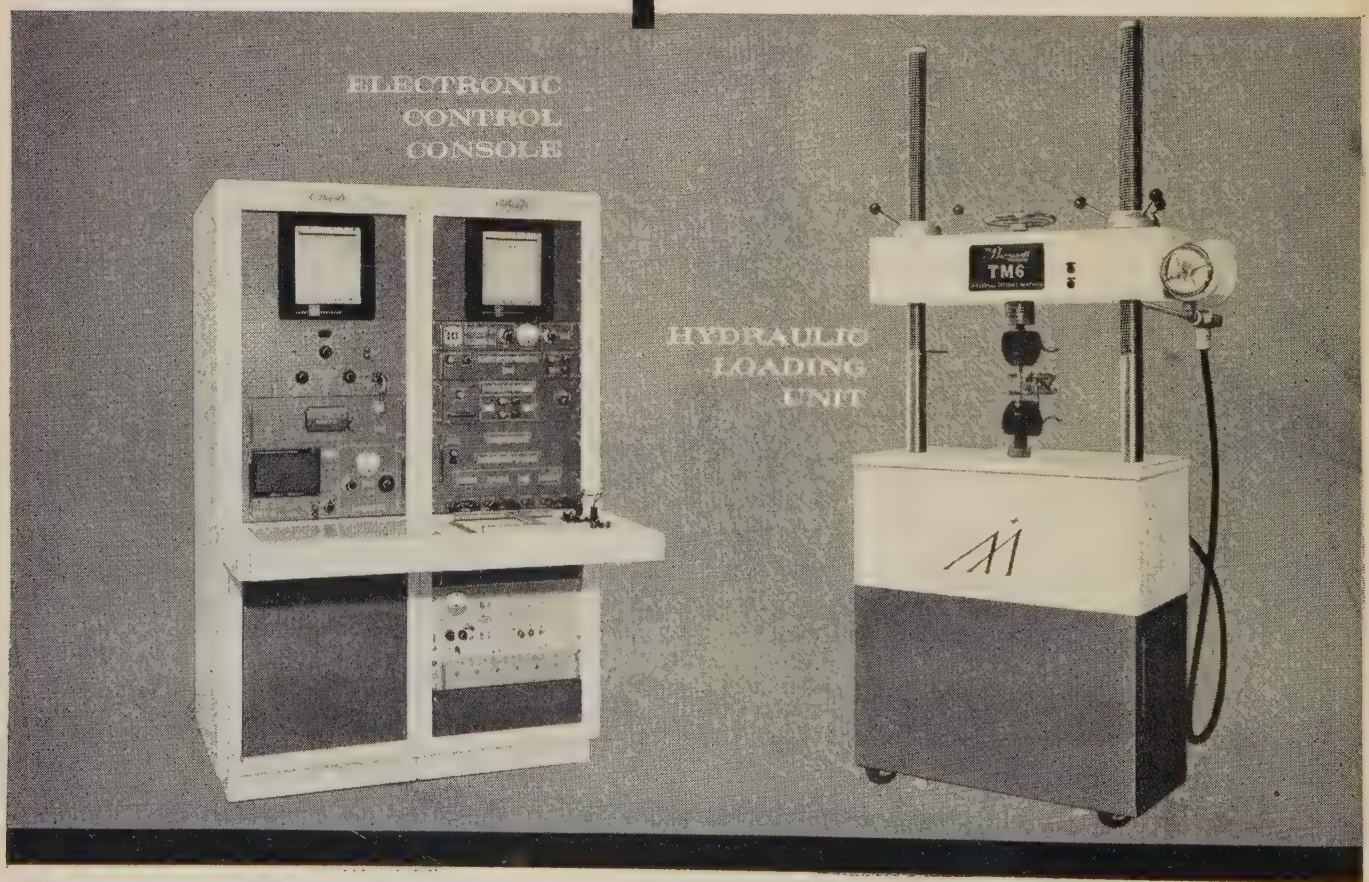




No. 40 on Reader Service Card

No. 162 on Reader Service Card

# ALLEN-BRADLEY TYPE TR RESISTORS

## are STANDARD for today's miniaturized hearing aids

Because of the engineering ingenuity of the manufacturers, hearing aids have become so tiny they are hardly noticeable—since the principal objection to wearing a hearing aid has been overcome, ever increasing thousands are enjoying this remarkable contribution to the joy of hearing.

Allen-Bradley is proud to play a part in this important development. The extremely tiny Type TR fixed resistor (actually smaller than a grain of rice) is used by virtually every hearing aid manufacturer to help achieve today's amazing miniaturization—without sacrificing reliability!

Tiny as they are, these miniature resistors—made by Allen-Bradley's exclusive hot molding process—*have never experienced catastrophic failure in service.* They are remarkably "uniform" to their resistance rating. Therefore, you are only fair to yourself—and your customers—when you insist on the reliability of the A-B Type TR resistors.

For complete details, please send for Technical Bulletin 5001, and Publication 6024 which also includes information on other A-B space-saving electronic components.

**SOME OF THE MANUFACTURERS OF HEARING AIDS WHO RELY ON A-B TYPE TR RESISTORS**

American Sound Products, Inc.
Audivox, Inc.
Beltone Hearing Aid Company
Busse Electronics Company
Dahlberg Company
Dictograph Products, Inc.
Electro Acoustic Research Labs., Ltd.
Gem Ear Phone Co., Inc.
Halhen Widex, Inc.
Johnston Hearing Aid & Electronics, Inc.
Maico Electronics, Inc.
The Microtone Company
E. A. Myers & Sons, Inc.
Otarion Listener Corp.
Qualitone Company, Inc.
Sonotone Corp.
Telex, Inc.
Unex Laboratories
Vari Electronics, Inc.

9-61-E

# ALLEN-BRADLEY

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis.
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QUALITY
ELECTRONIC COMPONENTS

# Non-Linear Systems, Inc. designs first digital voltmeter to satisfy critical standards for missile work

Digital voltmeters—originated by NLS—permit rapid and accurate voltage measurements. New Series 20 unit—with one plug-in decade board removed—shows the use of Allen-Bradley fixed resistors.

# Resistor Failures UNHEARD OF

...naturally, NLS uses ALLEN-BRADLEY hot molded resistors

To satisfy the high standards of consistent accuracy and reliability demanded for missile and weapons checkout, Non-Linear Systems, Inc., developed this digital voltmeter. It uses scores of Allen-Bradley fixed resistors. (For example, the latest Series 20 unit, shown above, contains about 1,000 in each instrument.) "In the selection of A-B resistors," says NLS, "quality and availability have never been a problem."

A-B resistors have such consistently uniform electrical characteristics that their performance can be accurately predicted over long periods of time under various operating conditions . . . with *complete freedom* from catastrophic failure while in service! The hot molding process used exclusively by A-B is the reason for this uniformity and reliability.

To obtain this same measure of superior performance for your equipment, always insist on Allen-Bradley quality fixed resistors available in various types. For full details, send today for your copy of Technical Bulletin 5000 or Publication 6024. Write to: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ontario.

ALLEN-BRADLEY

ALLEN-BRADLEY
Hot Molded Resistors
ACTUAL SIZE

Hot molded composition resistors are available in all standard EIA and MIL-R-11 resistance values and tolerances.

**Pending MIL Spec Assignment*

Type TR 1/10 Watt
MIL Type RC 06*
Type CB 1/4 Watt
MIL Type RC 07
Type EB 1/2 Watt
MIL Type RC 20
Type GB 1 Watt
MIL Type RC 32
Type HB 2 Watt
MIL Type RC 42

9-61-E

QUALITY
ELECTRONIC COMPONENTS

# How common salt led to an uncommon concept in communications.

An unusual new device to increase radio reflectivity, now under development at Northrop's Radioplane Division, may well revolutionize the field of space communications. Called ADSAT (for Anomalous Dispersion Spherical Array Target), it should extend the usefulness of passive communications satellites out to 22,000 miles—the 24-hour orbit.

The germ of the ADSAT idea actually came from early X-ray diffraction experiments with ordinary salt crystals which yielded a pattern of intense bright and dark spots. This hint of resonance with the crystal lattice led Northrop researchers to attempt to duplicate this effect at radio frequencies—and the first version of ADSAT looked much like a molecular model, with silver-coated ping-pong balls serving as "atoms." The size of the balls and the intervals between them were carefully calculated to resonate with and reinforce the incoming frequencies.

In its present, basic form, the ADSAT satellite is a collapsible, spherical network, 100 to 400 feet across, with the resonant balls at each intersection of the network. It is designed to be launched in a small package, and inflated in orbit, much like Echo. The reflected signal, however, can be 1,000 times as strong as that obtained from a simple, Echo-type target of equal size.

The development of the ADSAT concept demonstrates once again Northrop's unique ability to visualize problems in space technology, decide what should be done, and come up with solid, workable answers.

**NORTHROP**

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ANOTHER ADVANCED DEVELOPMENT FROM
RAYTHEON'S SPENCER LABORATORY
IR polarizer
Subminiature dewar (Pkg. 1)
Miniature dewar (Pkg. 2)
2-stage JT cooler & dewar (Pkg. 3)
$N_2$ & He storage dewar (Pkg. 4)

# IR detector line has extreme sensitivity, fast response time, 1-30 micron coverage

**Raytheon's rugged all-metal detectors are ideal for aerospace applications.**

A whole new order of infrared system capabilities is now being opened with the high sensitivity and fast response of these rugged all-metal detectors. The table at right and photo above tell part of the story of the 9 new types that combine various sensing materials, windows and cooling techniques in compact integrated packages.

Raytheon detectors provide coverage in the important long wavelength regions of 1 to 6, 6 to 9, 8 to 14, and 14 to 30 microns. Raytheon thin-film polarizer has 98% polarization at 4 microns and beyond.

For the complete story of the unique performance features of these IR detectors and polarizer, write for technical bulletin to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts.

RAYTHEON INFRARED DETECTORS

| TYPE | MATERIAL | WINDOW | PACKAGE | RESPONSE |
|---|---|---|---|---|
| QKN-748 | AuGe | Silicon | #1 | 1-9 microns |
| QKN-1003 | AuGe | BaF2 | #1 | 1-9 microns |
| QKN-884 | AuGe | Silicon | #2 | 1-9 microns |
| QKN-1004 | AuGe | BaF2 | #2 | 1-9 microns |
| QKN-961 | CdGe | BaF2 | #3 | 1-17 microns |
| QKN-902 | CuGe | BaF2 | #4 | 1-17 microns |
| QKN-1007 | CdGe | KRS-5 | #3 | 1-25 microns |
| QKN-1008 | CdGe | KRS-5 | #4 | 1-25 microns |
| QKN-1009 | CuGe | KRS-5 | #4 | 1-30 microns |
| IR Polarizer | | 98% polarization | | 4 microns & beyond |

RAYTHEON

RAYTHEON COMPANY

MICROWAVE AND POWER TUBE DIVISION



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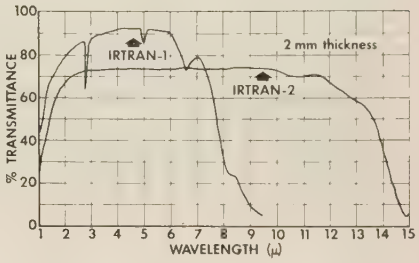
# KODAK COMPONENTS FOR INFRARED SYSTEMS

## KODAK IRTRAN OPTICAL ELEMENTS

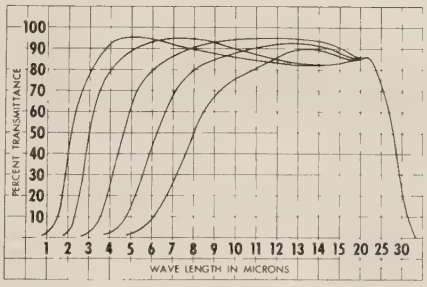
Kodak has developed a new class of "optical" materials for use in infrared and microwave systems and instruments. They retain high transmittance when hot (600°C and beyond). They are not injured by thermal shock, humidity, abrasion, weathering, organic solvents, 0.5N $HNO_3$, 1N $H_2SO_4$, 0.5N KOH, or 0.5N $NH_4OH$.

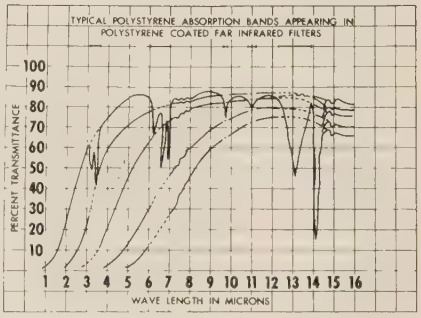
Irtran-1 material, low in refractive index, provides the best answer to the "dual-mode" problem. Infrared and microwave radiation can look through the same window. Irtran-2 material has the relatively high infrared refractive index of 2.2. Both materials we form and polish into lenses, domes, prisms, and flats.




## KODAK FAR INFRARED FILTERS

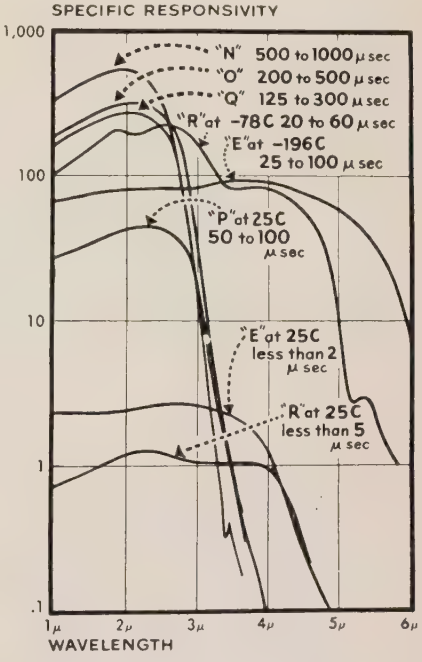
Kodak makes blocking filters of silver chloride with a silver sulfide layer that removes radiation up to a selectable wavelength between 1μ and 5μ. Series 200S filters have polystyrene protective coatings.





TYPICAL POLYSTYRENE ABSORPTION BANDS APPEARING IN POLYSTYRENE COATED FAR INFRARED FILTERS
PERCENT TRANSMITTANCE
WAVE LENGTH IN MICRONS

## KODAK EKTRON DETECTORS

These photoconductive resistors are made by depositing lead sulfide or lead selenide. They provide a wide-open choice in spectral response and time constant, and a wide-open choice of physical forms—large, small, complex shapes, multiple arrays, "immersed," Dewar-housed.


SPECIFIC RESPONSIVITY
"N" 500 to 1000 μ sec
"O" 200 to 500 μ sec
"Q" 125 to 300 μ sec
"R" at -78C 20 to 60 μ sec
"E" at -196C 25 to 100 μ sec
"P" at 25C 50 to 100 μ sec
"E" at 25C less than 2 μ sec
"R" at 25C less than 5 μ sec
WAVELENGTH

## SEND FOR THIS FACT-FOLDER

Kodak makes quite a few kinds of components for systems that detect, analyze, and otherwise respond to infrared radiation. In exchange for your name, address and company affiliation, we will gladly send you a folder full of our latest data sheets. (Things are moving too rapidly at present to permit the finality of a printed catalog.)

**EASTMAN KODAK COMPANY**
*Apparatus and Optical Division*
Rochester 4, N.Y.

Kodak
TRADE MARK

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# FROM MOTOROLA...

# POWER

NEW PNP GERMANIUM SERIES RATED AT

# 170 W. $P_d$

OPERATES UP TO

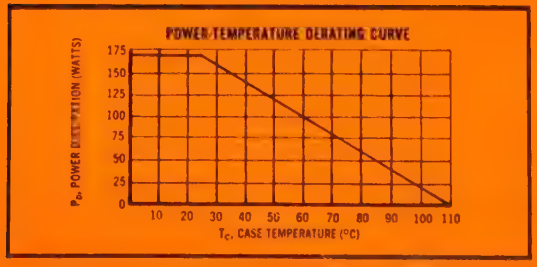
# 110° C. $T_J$

AVAILABLE WITH CERTIFIED RELIABILITY

# "MEG-A-LIFE"

## NEW 2N2075-82 SERIES OFFERS:

- **170 WATTS—93% greater power dissipation capability than conventional TO-36 power transistors.**
- **110° C. $T_J$ — Maximum junction temperature rating (15° higher than conventional TO-36 units) provides added operating temperature safeguard and also increases allowable power dissipation at any given case temperature. In over 3,000,000 device hours of storage life testing at temperatures up to 150°C. the failure rate was only 0.030%/1000 hrs.**
- **"MEG-A-LIFE"—a program offering industrial users certified reliability based upon complete electrical, mechanical, and environmental tests to military type specs. Lot acceptance data and test results available to purchasers of "MEG-A-LIFE" versions of these devices.**

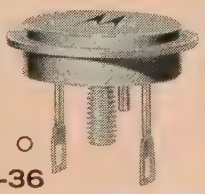



| 2N2075 SERIES, 15 AMP | | | | |
|---|---|---|---|---|
| $h_{FE}$ @ 5A | $BV_{CES}$ | | | |
| | 40V | 50V | 70V | 80V |
| 20–40 | 2N2078 | 2N2077 | 2N2076 | 2N2075 |
| 35–70 | 2N2082 | 2N2081 | 2N2080 | 2N2079 |

# THE LEADER IN TRANSISTORS

## Plus this most complete line of other TO-36 and TO-3 devices

TO-3



TO-36

### 3 AMP* $P_D = 90$ watts, $T_j$ max = 100°C

| $h_{FE}$ @ .5 A | $BV_{CES}$ | | | | |
|---|---|---|---|---|---|
| | 30V | 45V | 60V | 75V | 90V |
| 30–60 | 2N2137 | 2N2138 | 2N2139 | 2N2140 | 2N2141 |
| 50–100 | 2N2142 | 2N2143 | 2N2144 | 2N2145 | 2N2146 |

### 3 AMP $P_D = 90$ watts, $T_j$ max = 100°C

| $h_{FE}$ @ 1 A | $BV_{CES}$ | | | |
|---|---|---|---|---|
| | 40V | 60V | 75V | 100V |
| 60–140 | 2N1360 | 2N618 | 2N1363 | 2N1365 |
| 35–90 | 2N1359 | 2N375 | 2N1362 | 2N1364 |

### 5 AMP* $P_D = 90$ watts, $T_j$ max = 100°C

| $h_{FE}$ @ 3 A | $BV_{CES}$ | | | | |
|---|---|---|---|---|---|
| | 30V | 45V | 60V | 75V | 90V |
| 75–150 | 2N1544 | 2N1545 | 2N1546 | 2N1547 | 2N1548 |
| 50–100 | 2N1539 | 2N1540 | 2N1541 | 2N1542 | 2N1543 |
| 35–70 | 2N1534 | 2N1535 | 2N1536 | 2N1537 | 2N1538 |
| 20–40 | 2N1529 | 2N1530 | 2N1531 | 2N1532 | 2N1533 |

### 10 AMP $P_D = 90$ watts, $T_j$ max = 100°C

| $h_{FE}$ @ 10 A | $BV_{CES}$ | | | |
|---|---|---|---|---|
| | 30V | 45V | 60V | 75V |
| 10–30 | 2N627 | 2N628 | 2N629 | 2N630 |

### 15 AMP $P_D = 150$ watts, $T_j$ max = 100°C

| $h_{FE}$ @ 5 A | $BV_{CES}$ | | | | |
|---|---|---|---|---|---|
| | 40V | 45V | 50V | 70V | 80V |
| | | | | $h_{FE}$ 25–50 | $h_{FE}$ 25–50 |
| 20–40 | 2N441 | 2N442 | 2N443 | 2N174 | 2N1100 |
| 35–70 | 2N277 | 2N278 | 2N173 | 2N1099 | |

### 15 AMP* $P_D = 90$ watts, $T_j$ max = 100°C

| $h_{FE}$ @ 10 A | $BV_{CES}$ | | | |
|---|---|---|---|---|
| | 30V | 45V | 60V | 75V |
| 50–100 | 2N1557 | 2N1558 | 2N1559 | 2N1560 |
| 30–60 | 2N1553 | 2N1554 | 2N1555 | 2N1556 |
| 10–30 | 2N1549 | 2N1550 | 2N1551 | 2N1552 |

### 25 AMP* $P_D = 90$ watts, $T_j$ max = 100°C

| $h_{FE}$ @ 25 A | $BV_{CES}$ | | |
|---|---|---|---|
| | 35V | 60V | 75V |
| | 2N1162 | 2N1164 | 2N1166 |
| 15–65 | 2N1163 | 2N1165 | 2N1167 |

### MILITARY TYPES

| | $BV_{CBO}$ | $BV_{CES}$ | $h_{FE}/I_C$ |
|---|---|---|---|
| JAN 2N174 | 80V | 70V | 40–80/1.2A |
| 2N297A (Sig C) | 80V | 50V | 20 min/2A |
| 2N297A | 80V | 50V | 20 min/2A |
| 2N1011 (Sig C) | 80V | 80V | 30–75/3A |
| 2N1011 | 80V | 80V | 30–75/3A |
| 2N1120 (Sig C) | 80V | 70V | 20–50/10A |
| 2N1120 | 80V | 70V | 20–50/10A |
| 2N1358 (Sig C) | 80V | 70V | 25–50/5A |
| 2N1358 | 80V | 70V | 25–50/5A |
| 2N1412 (USN) | 100V | 80V | 25–50/5A |
| 2N1412 | 100V | 80V | 25–50/5A |

*Available in "Meg-A-Life" types

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# MAN, SPACE and INFRARED

**The year 1961 will ever be remembered as one of great accomplishments, as a year in which many major scientific breakthroughs were made, for it marked a tremendous stride forward in the parade of human achievement. Man, at last, has learned to break his bonds, and for the first time leave his familiar Earth environment and venture into the inhospitable emptiness of space . . . Fortunately, the fundamental laws of physics apply in space just as they govern on earth; the laws which describe the phenomena of infrared physics are valid in space, and are the same as those with which we are so familiar.**

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**TIROS:** Wide-field and narrow-field radiometers, and radially-oriented horizon sensors

**MERCURY:** Horizon sensors for the manned spacecraft

**NIMBUS:** Wide-field radiometer

**AGENA:** Horizon sensors

**MARINER:** Terminal-guidance navigation sensor

**POLARIS:** PEAC" Photo-electric Autocollimator

**DAMP:** Missile re-entry measurements

**NASA — Weather Bureau:** Satellite-borne spectrometer

**TRACKERS:** for Atlantic and Pacific Missile Ranges, and for White Sands Proving Grounds

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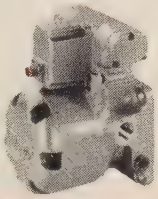
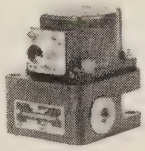
BENDIX HYDRAULIC PUMPS, MOTORS, SERVO VALVES, ACTUATORS

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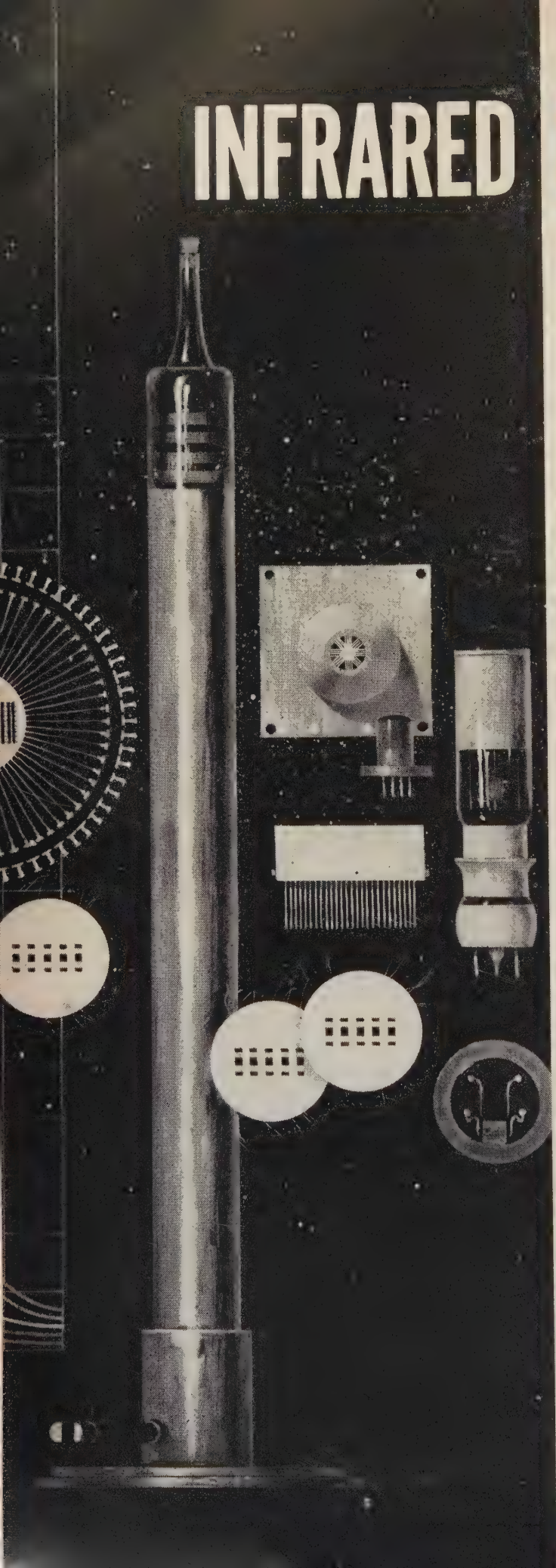



# INFRARED DETECTORS

## NEW DESIGNS, NEW APPLICATIONS

**by Bernard Kovit,** Associate Electronics Editor

FOR ALL THE TROUBLES they have had and still have, the designers of IR detectors can look back with pride on what they have achieved. IR detectors today are orders of magnitude better than those available before 1950—better both in their ability to detect small amounts of radiation and in their selective performance in various spectral regions.

No staggering sums are being spent for R&D on IR detectors for aerospace applications—probably the annual figure is somewhat below $20 million. The R&D money spread around by the military and NASA is mainly going into many small-scale special studies. Most—if not all—the companies in the field also spend considerable funds of their own on R&D. Once any of this R&D work starts paying off, the annual IR detector market could easily double.

With such notable successes as Sidewinder and Falcon behind them, the IR systems designers have been trying to apply IR to new and pressing problems, including those of ballistic missile detection and interception, spacecraft stabilization, interplanetary navigation, and the exploration of atmospheres. Few doubt that once we are in outer space, a glorious new era will dawn for the entire IR-optics technology.

IR detector specialists believe they have already come up with devices that are in many cases more sensitive and capable than what current aerospace systems need or can use. On the other hand, they don't pretend that they aren't having their troubles—troubles that clearly are aggravated by a multitude of parallel R&D programs, by the vast scope of the materials research implied by IR work, and by serious problems of communication between design groups.

DOD, BuWeps, and ASD have been working with industry on the problems of IR standards and terminology, and directives on standards have recently appeared. The problems involved in arriving at figures of merit and more specific methods of describing other properties of detectors are enormous, but considerable progress is being made in this direction.*

IR detectors fall into two main classes:

- *Point detectors* have a sensitive surface (usually of a solid-state material) that integrates all incident radiant energy and provides a single electric signal. They include both thermal and quantum types.

* See C. Ravitsky, C. Cumming, T. Moss, "Standard Procedure for Target and Background Infrared Measurements," Off. Dir. Def. Res. & Engrg., Apr. '61. R. Jones, D. Goodwin, G. Pullan, "Standard Procedure for Testing Infrared Detectors and for Describing Their Performance," Off. Dir. Def. Res. & Engrg., Sep. '60. "Standard Laboratory Measurement System Operation Procedure," OTS PB 171238, Apr. '60. W. Harrison et al, "Standardization of Thermal Emittance Measurements," WADC Tech. Dep. 59-510, '60. "Criteria for the Performance of Infrared Systems," Aerojet-General Rep. 1610, May '59. "Precision Measurement and Calibration Optics, Metrology, and Radiation," Handbook 77, vol. III, Dept. Commerce, Feb. '61.

• *Area, or extended, detectors* have a surface that provides information about the values of irradiation at its various points—they give you a picture of the radiation that reaches them from the field of view. In this class belong image tubes, vidicons, evaporographs, etc. Though this type once was just about limited to the near IR region (0.7-1.5 microns), it has now been extended to the longer IR wavelengths.

Ballistic missile tracking, star tracking, groundmapping from satellites, and surveillance are among the applications of the newer image tubes. A fair amount of development work is being done on linear- and mosaic-array (two-dimensional) thermal imaging. For camera tubes, the IR vidicon is getting a lot of attention. Two approaches are being taken: the thermistive (Westinghouse's "thermicon" and General Electrodynamics' thermal imager) and the photoconductive (on which GE, Hughes, Lincoln Labs, RCA, and others are working). Like point detectors, photoconductive vidicons won't go beyond the 1.5-5-micron region; for the longer wavelengths, the thermicon-type is more practical.

IR vidicons hold many advantages for space applications. Next to ranging, getting an accurate bearing is one of the biggest problems in space. Because of the ease and speed with which you can move an electron beam—in contrast with mechanical search-track methods—the IR camera tube has found much support. Also, in space you have extremely high accelerations to contend with, which makes the speed-of-light electron beam a logical contender.

## Describing Detector Performance

The performance of IR detectors is characterized primarily by the strength of the electric signal generated by a given radiation input and by the ratio of this signal to the noise. In addition, the spectral region of operation, the frequency bandwidth, impedance, variations in detecting ability over the surface, and the theoretical limit of the detector must be considered.

The input to an IR detector is radiant power in a certain spectral region. The detector responds to it yielding a voltage or a change in voltage. When this effect is linear, the output-input ratio of the detector is the responsivity (R), usually in volts per watt.

Users of detectors demand some way of specifying the smallest detectable signal amount or the "noise equivalent power" (NEP), defined as the amount of power on the detector surface that will yield an RMS voltage exactly equal to the RMS value of the detector noise voltage. Detectivity (D) then is the reciprocal of NEP:

$$R = V_s/P,\ NEP = \frac{P}{V_s/V_n},\ D = 1/NEP = \frac{P}{V_s/V_n}$$

where $V_s$ is the signal voltage; $V_n$ the RMS noise voltage; and P the RMS radiant power. R, NEP, and D are very useful to know when a detector is to be included in a particular piece of equipment, but the system designer also must have a way to compare the performance of different detectors. R. C. Jones, of Polaroid, has proposed several figures of merit derived by normalizing D with respect to some of the parameters on which it depends.

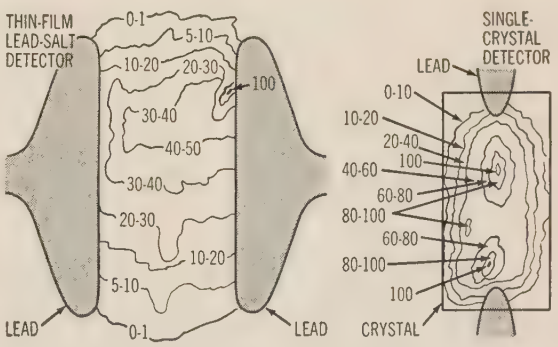
Since detectivity changes as the reciprocal of the reciprocal of the square root of the area (A) and as the reciprocal of the square root of the bandpass ($\Delta f$), Jones proposes:

$$D^* = (A\Delta f)^{1/2}\, D.$$

$D^*$ can be defined either for radiation from a black body or for a monochromatic light source; furthermore, because of the noise characteristics of the detector, $D^*$ is usually dependent on the chopping frequency. $D^*$ therefore can be written with independent variables $D^*(T,f)$ and $D^*(\lambda,f)$ where T is the temperature of the test black body; $\lambda$, the wavelength of measurement; and f, the chopping frequency. Finally, $D^*$ can depend on the field of view of the detector (if the photon fluctuation noise is appreciable). This gives Jones:

$$D^{**} = (\Omega/\pi)^{1/2}\, D^* = (\Omega/\pi)\,(A\Delta f)^{1/2}\, D,$$

where $\Omega$ is the solid-angle field of view of a detector that is assumed to radiate equally in all directions.




Usually the relative response of a detector to radiations of different wavelengths is measured and a value of $D^*$ is derived for a narrow spectral band. The relative response can then be given absolute values. The plot of $D^*$ vs $\lambda$ that results is probably the most important indicator of detector performance. Next in importance are the constant of frequency response and the noise bandwidth ($\Delta f$).

The sensitive area of a detector—especially one that has an irregular sensitivity contour—is a particularly difficult characteristic to define, even though the concept of area is quite simple. A common compromise is to plot sensitivity contours, usually taking as the sensitive area the region between the electrodes (see Plots).

**Imaging IR Detectors**

| | Operating Principle | Cutoff (microns) | Response Time (sec) | Relative Efficiency |
|---|---|---|---|---|
| Cesium cathode-image tube | external photo-effect | 1.2 | $10^{-6}$ | 1 |
| IR camera | photographic | 1.2 | 1/60 | 0.002 |
| Phosphorescent image tube | quenching of phosphor | 1.2 | $0.1\text{-}10^{-4}$ | 0.005 |
| Evaporograph | rapid evaporation of IR-volatile oil from absorbent surface at near-vacuum pressure | 16 | 8-10 | 0.001 |
| Edgegraph | shift of semiconductor absorption edge with temperature change | 0.01-0.5 | 20 | 0.075 |
| IR vidicon | televising of changes in photoductive surface | 5 | | |
| Thermal imaging devices | change in vapor pressure, physical dimensions, wavelength of optically absorbing edge, or dielectric constant | 35-40* | 0.003-0.1 | 0.8 |

*Can be extended to 1000 and beyond, depending on the absorptivity of the surface coating.

Because several of the developmental imaging devices are quite close to the final prototype stage and military contracts are in the offing, few details of actual designs and their performance are being given out. The indications are that IR image tubes may soon compete with the conventional point detectors for many tracking and surveillance roles (though no one believes that the latter will therefore become obsolete).

Best suited, generally, to the visible and near-IR spectral regions are photocells, certain photoconductors, dielectric cells, and thalofide detectors. Photoconductive point detectors respond better to weaker temperature sources and are unsurpassed for the middle IR region (1.5-5.6 microns). They are being used most widely for target detection, ranging, in search and track systems, and in radiometers. Intensive R&D is being done on photoconductor materials, with the emphasis on developing materials that will not require extreme—or, ideally, any—cooling to reach the required levels of sensitivity.

The most recent developments in detector materials—particularly those that need no more than dry-ice temperatures—and in view-angle techniques have extended

## The Users Ask . . . The Manufacturers Answer

**Q. What is the ultimate sensitivity of a given detector and how much more must we pay to get it?**

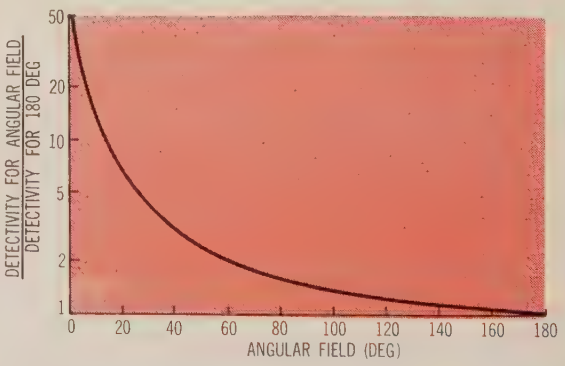
**A.** R. Clark Jones, of Polaroid, rightly points out that the use of the word "sensitivity" is quite confusing to begin with—it can mean either responsivity or detectivity, two very different things. If you multiply the incident power by the responsivity, you get the voltage output, but multiplying this power by the detectivity gives you S/N. Presumably, though, the point in question is detectivity (D*).

Almost all the manufacturers who responded to SPACE/AERONAUTICS' survey believe D* in the end is limited by the target radiation noise—a limit that we apparently haven't come anywhere near yet. Many current detectors are considered to be background-noise-limited, which only means that the lattice generation-recombination noise has been reduced by lowering the temperature of the detector until the background noise predominates. Often background noise can be minimized by reducing the view angle and/or lowering the temperature of the optics (see Graph).

There is a fair number of detectors whose detectivity comes close to the background limit, but as these absorb IR via impurities rather than by the fundamental bandgap, they must be cooled to much lower temperatures than is needed with bandgap detectors. The present ultimate D* probably is around $2\text{-}3\times10^{10}$ for photovoltaic detectors at 78 deg K. A value of $1.5\times10^{10}$ has been reported for PEM detectors. Other sources put the highest D* of available photovoltaic InSb at $5\times10^{9}$ and that of PbSe at $5\times10^{8}$.

Several experts foresee great improvements through cutting detector self-noise, further cooling, and the elimination of imperfections responsible for 1/f noise. Others point out that the biggest improvement will be the development of detectors that need less cooling—and are generally considered to be a long way off.

All that can be said about price is that it depends on the complexity and precision of the system in which the detector is used—its optics, cooling, type of scan, etc.—and on the vehicle. Non-standard detectors, of course, cost more, but detector specialists point out that the systems engineer should first make certain that such a detector is actually needed before he issues his spec. They all agree that a detector specialist should be consulted early in the design planning stage.




**Q. What can be done to meet tightening requirements for miniaturization?**

**A.** Manufacturers unanimously claim that detectors have already been adequately miniaturized and that the problem now is to cut the size of the cooler or dewar. Single elements of linear and multiple arrays today measure as little as 150X150 usec in the receiving area. Barnes and others are producing even smaller elements by micro-depositing, and printing. Cooled germanium detectors in 1.25-in.-long, 0.5-in.-diameter dewars have been built as a result of the miniaturization work of firms like Raytheon and Texas Instruments.

**Q. What's being done to provide smaller, long-term, cryogenically cooled detector packages?**

**A.** Air Products, A. D. Little, Norden, North American

he detectivity of impurity-activated quantum detectors out to the 6-40-micron region (single germanium and Ge-S crystals with such impurity additions as gold, copper, zinc, and antimony) and even to 120 microns (antimonide-doped germanium and silicon). Great emphasis is being put on the development of detectors for 8-14 microns, which would take advantage of the atmospheric transmission window in that region. A new mercury-doped germanium detector, for instance, reportedly has a near-optimum response in this window using a 60 deg aperture and with only 40-deg K cooling. Formerly, liquid-helium temperatures were needed with similar devices.

Most of the latest single-crystal detectors approach the theoretical detectivity limit within a factor of 2-3. Still, a great deal of R&D is needed beyond 10 microns.

Thermal point detectors—thermocouple, thermopile, and IR bolometer types—and thermal imaging devices are more responsive to weaker temperature sources over wide bands in the far IR spectral region (5.7-1000 microns). Their usefulness is greatly enhanced by the fact that generally they can get along without chopping or cryogenic cooling. Radiometry, thermal mapping, and surveillance are among their most common applications. Advanced work is aimed at producing better and smaller imaging devices and spectrally selective thermal point detectors.

Some of the more ambitious development studies sponsored by USAF are devoted to passive ranging. Most of them involve some form of triangulation through interferometric techniques. They include absorption ranging, which depends on the IR-sensitive materials used in the detector and in which you measure the change in the absorption of incident IR as the target moves through the atmosphere, and range-rate detection, which depends on the angle on the target and in which you measure the rate of change in the intensity of sensed radiation from an opening or closing target. Surface or target irradiation changes due to fluctuations related to a change in range are also being studied.

All these approaches to passive ranging focus attention on one of the most puzzling questions still facing the IR detector designer: Just how and what does an IR detector sense?

## A Space/Aeronautics Survey of Current IR Detector Problems

Philips, and others are developing miniature cryostats and coolers but so far we do not have a reliable long-term design. Hughes, for instance, has developed a closed-cycle, liquid-helium cryostat that reportedly uses a Claude-type thermodynamic cycle to cool the gas to a temperature at which Joule-Kelvin cooling can take place.

Cryogenerators, a Philips subsidiary, is getting ready to market a miniature closed-cycle, liquid-helium cryogenerator based on a reversed Sterling-engine cycle that will stay below 30 deg K for indefinite periods. Most aerospace IR detectors now use open-cycle cooling, which even with intermittent use lasts only a few days at best.

Most of the development work in this area is being done by the companies themselves, some of whose engineers believe success would come sooner if there were more government-sponsored programs.

Several experts also believe that in the end we will go to thermoelectrically cooled IR packages. Radiation Electronics reports it is getting ready to produce such a package that cools to dry-ice levels in a 25-30-deg C ambient, uses only 2½ amp, and operates indefinitely.

**Q. What ever became of the maser and paramp IR detectors?**

**A.** Apparently, the basic problems have defied solution, though some work is still being done. Moreover, a Raytheon engineer points out, it's not certain whether such detectors would be any more sensitive in the IR region than present quantum detectors. While the optical maser (laser) amplifier is particularly attractive because it promises coherent IR energy transmission in very narrow bands, like the maser and IR detector it has the drawback of being restricted to narrow-band detection. Thermal radiation, of course, covers a wide band of wavelengths and requires a wideband detector.

Even if this restriction were acceptable, maser and paramp IR detectors would be limited by the same physical factors as the present photo-effect devices—the photon blip detector noise limits. Maser and paramp IR detectors might, however, be used to advantage as imaging devices if methods of signal enhancement by background coding could be devised.

**Q. Has research on photoconductive-detector materials reached a dead end?**

**A.** No manufacturer appears to believe that it either has or will in the foreseeable future:

"There is no impasse on materials development within the framework of modern solid-state techniques. It's possible to tailor materials for any required wavelength response characteristics, fast response time, and high sensitivity."—Martin

"No. Purity development must be studied as well as doping. These may lead to more sensitive detectors or detectors with wider wavelength sensitivity or both."—Radiation Electronics

"As IR materials technology improves, more materials show properties that are suited for IR detectors. Recent advances in impurity-activated germanium should be possible for many other types of semiconductors. There are also many new compound semiconductors that have not yet been thoroughly studied for detector application—particularly the long-wavelength detectors. The problem actually is that there are too many possibilities remaining, not too few, and this has diluted the efforts of the IR detector manufacturers."—Block Associates

"We feel that photoconductive detectors composed of polycrystalline thin films are not the answer to military detector requirements. The single-crystal, solid state detectors such as InSb, copper-doped germanium, silicon, indium arsenide, and more exotic compound semiconductors do a much better job of supplying maximum detectivity, reliability, and uniformity."—Texas Instruments

"There still is the entire untouched field of organic semiconductors"—Aerojet-General.

# QUANTUM POINT DETECTORS

**by W. L. Wolfe and T. Limperis,** Information & Analysis Center,
Infrared Laboratory, Institute of Science & Technology, The University of Michigan*

AN AIR RADIATION TRANSDUCER basically works by absorbing a photon, or quantum of radiation. You could therefore say that all detectors are quantum detectors. A distinction is made, however, according to how a detector responds to the absorbed photons:

- In *thermal* detection, the photons are absorbed by a process that transfers their energy to phonons, or lattice vibrations, and a local temperature rise is detected.
- In *quantum* detection, the absorbed photon causes some change in the state of the electron distribution and a measure of this change is used for detection.

There are several kinds of quantum detectors, most of which are in wide use in IR equipment (*Fig. 1*):

- In *photoemissive* detectors, the absorbed IR photon causes the emission of an electron from the surface.
- In *photoconductive* detectors, the absorbed IR photon causes electrons in the valence band or impurity levels to move to the conduction band, increasing the conductivity of the semiconducting material.
- In *photovoltaic* detectors, photons create free

* The University of Michigan, Ann Arbor, Mich.

## Characteristics of Quantum Detectors

### Photoconductive Lead Salt[A]

| Material | Cell Temp (deg K) | Impedance (megohms) | Wavelength of Peak D* ($cm^{-1}$-cps $^{1/2}$-$W^{-1}$) | Threshold Wavelength (microns) | Noise Voltage[B] (uv) | D* ( ,90,1) ($cm^{-1}$-cps $^{1/2}$-$W^{-1}$) | Time Constant (usec) | Preparation | Manufacturers |
|---|---|---|---|---|---|---|---|---|---|
| PbS | 77 | 0.510-20 | 2.5 | 3.8 | 20 | $5\times10^{9}$ | 500-3000 | chemically deposited | Eastman Kodak, Electronics Corp. of Am., Infrared Ind., Santa Barbara Res. Center |
| | 195 | | 2.6 | 3.2 | | $\sim5\times10^{10}$ | 900 | chemically deposited | Eastman Kodak, Electronics Corp. of Am., Infrared Ind., Santa Barbara Res. Center |
| | 300 | 0.3-2.0 | 2.4 | 2.7 | 0.5-1.5 | $\sim5\times10^{10}$ | 10-150 | evaporated | Jean Turk (France) |
| | | 1-10 | 2-2.4 | 2.3-3.1 | 0.6 | $\sim10^{11}$ | 150-500 | chemically deposited | Eastman Kodak, Electronics Corp. of Am., Infrared Ind., Santa Barbara Res. Center |
| PbSe | 77 | 2-100 | 5.0 | 6.0 | 1-4 | $1.6\times10^{10}$ | 10-30 | chemically deposited | Infrared Ind., Librascope, Santa Barbara Res. Center |
| | | 2-20 | 3 | 4.3 | 1-12 | $2\times10^{10}$ | 10-30 | evaporated | Avion |
| | 195 | | 3.3 | 3.8 | | $5\times10^{10}$ | | evaporated | Infrared Ind., Santa Barbara Res. Center |
| | | 20 | 4.5 | 5.1 | ~3 | $4.4\times10^{10}$ | ~18 | chemically deposited | Santa Barbara Res. Center |
| | 300 | 1.0-5.0 | 2.0 | 3.5 | 0.4-1 | $3\times10^{9}$ | 1-10 | evaporated | |
| | | ~0.05 | 3.5 | 4.3 | ~2.5 | $5\times10^{8}$ | 1-10 | chemically deposited | Infrared Ind., Santa Barbara Res. Center |
| PbTe | 77 | 50-1000 | 5.0 | 5.4 | 1-6 | $8\times10^{9}$ [C] | 1-10 | chemically deposited | ITT |

### Indium Antimonide Detectors

| Material | Operation | Cell Temp. (deg K) | Impedance (megohms) | Peak Wavelength (microns) | Threshold Wavelength (microns) | Peak D* (cm-cps$^{1/2}$-$W^{-1}$) | Time Constant (usec) | Noise Voltage[E] | Manufacturers |
|---|---|---|---|---|---|---|---|---|---|
| InSb | photovoltaic (diffused junction) | 78 | 0.001-0.01[F] | 5.0 | 5.3 | $2\times10^{10}$ | ~1 | 0.001-0.15 | Philco (Lansdale), Texas Instruments |
| | photovoltaic (grown junction) | 78 | 0.044[F] | 5.5 | 5.7 | $10^{10}$ | <2 | | Avco Crosley, Chicago Midway Labs., Polan Ind., Radiation Electronics |
| | photoconductive (high impedance) | 78 | 0.001-0.01 | 4.8 | 5.6 | $6\times10^{10}$ | <1 | 0.15 | Block Assoc., Chicago Midway Labs., Minneapolis-Honeywell, Northwestern U., Radiation Electronics, Texas Instruments |
| | photoconductive (low impedance) | 195 | 10-100 | 5.8 | 6.1 | $8\times10^{9}$ | <1 | | Radiation Electronics, Texas Instruments |
| | photoelectro-magnetic | 300 | 4.5-90 | 6.0 | 7.0 | $2\times10^{8}$ | <1 | 0.003 | Minneapolis-Honeywell, Radiation Electronics, Texas Instruments |
| InSb:Au[G] | photoconductive | 78 | | | | | | | |
| InSb:Ag[H] | photoconductive | 78 | | | | | | | |
| InSb:X[G] | photoconductive | 2 | | 3000 | 4000 | | | | |

(A) The field of view of these cells is about two steradians. Some cooled PbSe cells, however, which are close to the background-limited condition, are available with fields of view of 60 deg. In many cases, one parameter may be optimized at the expense of others by controlling the manufacturing process (e.g., the time constant may be reduced at the expense of D*). (B) A-f=90 cps and f=1, (C) A-f=900 cps. (D) Experimental detectors reported by Van Vliet (at 1961 Photoconductivity Conference, Ithaca, N. Y.)

carriers at the junction of N- and P-type material, so that a potential difference is developed.

• In *photoelectromagnetic* (PEM) detectors, a magnetic field separates the oppositely charged carriers, so that a voltage is generated.

• In three experimental types of detectors, the absorbed photons cause, respectively, a change in the dielectric constant, the population of metastable states, or the lateral voltage.

The lead chalcogenide detectors—PbS, PbSe, and PbTe—were the first aerospace quantum detectors (see *Table*).** They are produced by evaporating or chemically depositing films on insulator substrates. Heated in an oxygen atmosphere, the films then become photosensitive.

These films can be deposited in many geometric configurations. As it depends on cell geometry, cell impedance therefore can vary greatly. Also, as impedance, time constant, and noise equivalent power (NEP) depend on the degree of oxygenation, you can control them and so tailor the detector to your requirements.

Impurity-activated germanium is used extensively in military IR applications, with detector elements ranging from 0.2×1×1 to 5×5×5 mm (see *Table I*). Because of its intrinsic bandgap, it has a threshold wavelength of 1.75 microns. However, by adding impurities to the

** The characteristics given in the *Table* and throughout this article assume that when the detector is immersed in a 300-deg-K radiation field—even if the detector element is cooled—it "sees" a 300-deg-K background. For space applications, you must therefore make a special point of evaluating those characteristics that are strongly affected by background radiation. Certain space environments also have intense levels of nuclear radiation that drastically degrade detector characteristics. So far, very little materials research has been done in this area other than on the lead salts.

## Impurity-Activated Germanium Detectors

| Material | Impedance (megohms) | Wavelength at Peak D* (microns) | Threshold Wavelength (microns) | Cell Temperature (deg K) | Peak D* (cm-cps-W $^{-1}$) | Time Constant (usec) | Field of View (deg) | Manufacturers |
|---|---|---|---|---|---|---|---|---|
| P-type Ge:Au | 0.1-5 | 5 | 7 | 78 | $1.5\times10^{10}$ | <0.1 | 180 | Philco (Lansdale), RCA, Raytheon, Santa Barbara Res. Center, Westinghouse |
| N-type Ge:Au | 1-40 | 1.5 | ~4 | 78 | $1.5\times10^{11}$ | ~50 | ~180 | Philco |
| Ge:Hg | | 9 | 13 | 35 | $2\times10^{10}$ | <1 | 60 | |
| Ge:Cu | 0.00001-0.001 | 22 | 30 | 15 | $3\times10^{10}$ | <1 | 60 | RCA, Raytheon, Santa Barbara Res. Center, Texas Instruments |
| Ge:Cd | | 17 | 24 | 25 | $2.7\times10^{10}$ | <1 | 60 | |
| Ge:ZnI | ~2 | 36 | 36 | 4 | $2\times10^{10}$ | <0.1 | 60 | Perkin-Elmer |
| Ge:Mn[D] | | | ~8 | 78 | | <1 | | |
| Ge:Sb[D] | | | 130 | 4 | | <1 | | |

## Ge-Si:X Detectors

| Materials[J] | Cell Temp. (deg K) | Time Constant (usec) | Wavelength of Peak D* (microns) | Impedance (megohms) | Threshold Wavelength[K] (microns) | Peak D* (cm $^{-1}$-cps $^{1/2}$-W $^{-1}$) | Field of View (deg) |
|---|---|---|---|---|---|---|---|
| Ge-Si:Au-I[I] | 21 | <1 | 9.5 | 170 | 11.6 | $1.2\times10^{10}$-$2\times10^{10}$ | 120 |
| | 50 | <1 | 9.5 | 0.5 | 11.6 | $8\times10^{9}$ | 120 |
| Ge-Si:Zn-II[2] | 21 | <1 | 11.2 | 70 | 14 | $3.6\times10^{10}$ | 70 |
| | 50 | <1 | 11.0 | 30 | 14 | $1.5\times10^{10}$ | 70 |
| Ge-Si:Au-II | | | 4.5 | | 6 | | 180 |
| Ge-Si:ZnAu-II | 50 | | 4, 11[L] | | | $1.6\times10^{9}$[M] | |

## Other Detectors

| Material | Operation | Cell Temp. (deg K) | Wavelength of Peak D* (microns) | Impedance (K) | Peak D* (cm-cps$^{1/2}$-W $^{-1}$) | Time Constant (millisec) | Manufacturers |
|---|---|---|---|---|---|---|---|
| Te | photoconductive | 78 | 3.5 | 0.5-2 | $4.8\times10^{10}$ | 0.6 | Minneapolis-Honeywell |
| InAs | photovoltaic | 300 | 3.5 | 0.025[F] | $10^{10}$ | 0.02 | Philco (Lansdale) |
| CdS | photoconductive | 300 | 0.5 | $1.6\times10^{5}$-$10^{7}$ | $10^{11}$-$10^{14}$ | 12-300 | AEG (West Germany), Northwestern U., Practical Electronics Mfg. |
| CdSe | photoconductive | 300 | 0.5-0.75 | $5\times10^{3}$-$10^{7}$ | $5\times10^{11}$ | 6-60 | AEG (West Germany), Hilger & Watts (England) |
| Se-SeO | photoconductive | 300 | 0.58 | $10^{7}$ | $3\times10^{10}$ | 2 | Weston Brake & Signal (France), Weston Instr. |
| GaAs | photovoltaic | 300 | 0.85 | 500-1500[F] | $1.2\times10^{12}$ | 1 | Philco (Lansdale) |

and H. Levinstein, of Syracuse U., respectively. (E) A+Δf=1. (F) Dynamic impedance. (G) Experimental detectors reported by S. Borrello et al., Proc. IRIS, 6/2, '61, and E. H. Putley at '61 Photoconductivity Conference, Ithaca, N. Y., respectively. (H) Experimental. (I) NEP=$5\times10^{-11}$W. (J) Roman numerals indicate the level of the impurity addition. (K) The wavelength at which D* has been degraded by 50 per cent from peak D*. (L) For GE-Si:Zn and Ge-Si:Au-II, respectively. (M) D* (500 deg K, 1500, 1).

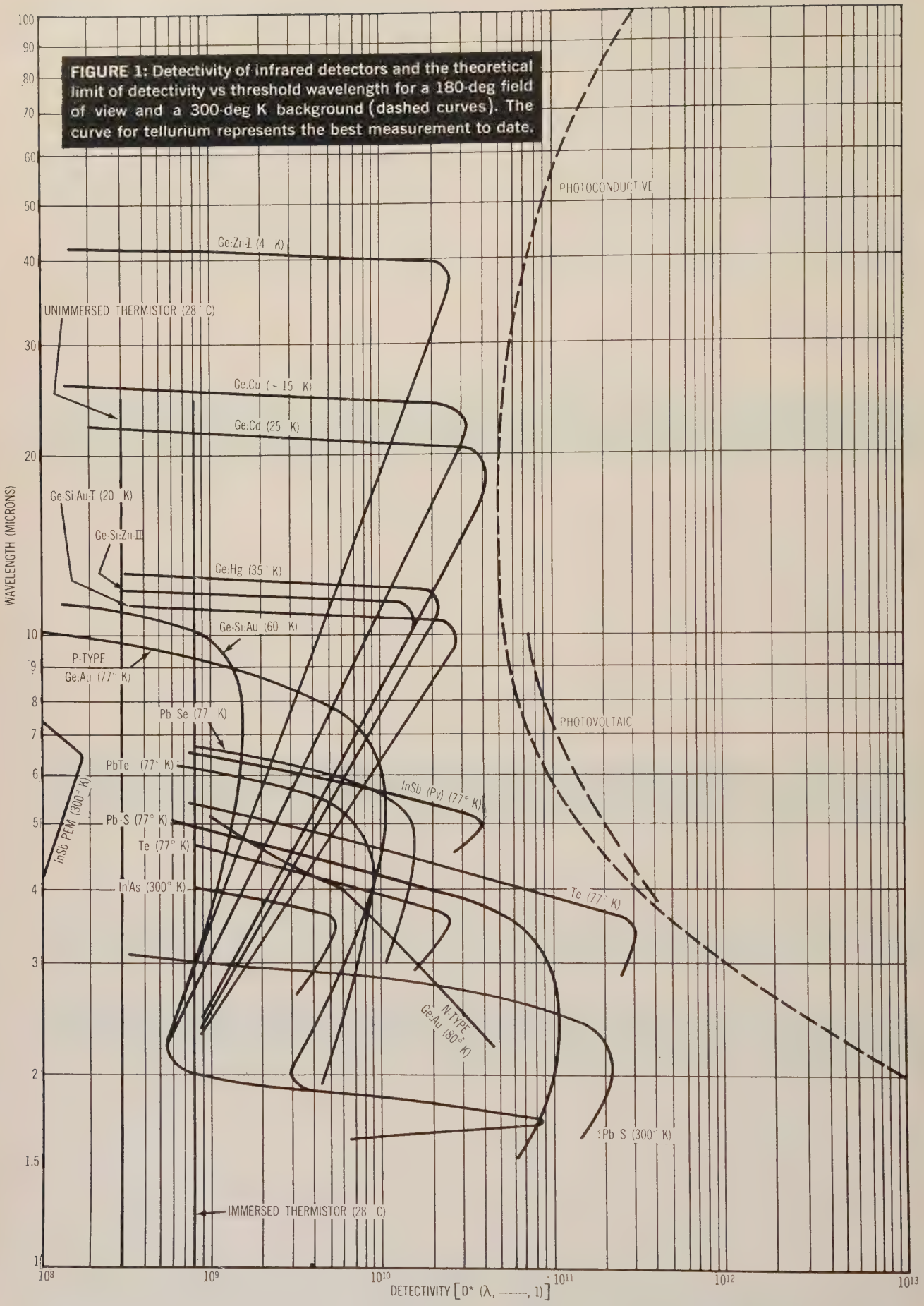



**FIGURE 1:** Detectivity of infrared detectors and the theoretical limit of detectivity vs threshold wavelength for a 180-deg field of view and a 300-deg K background (dashed curves). The curve for tellurium represents the best measurement to date.

lattice, you can get an intrinsic response beyond three microns (*Fig. 2*).

When impurities are added and the interaction of signal photons with lattice takes place at an impurity center, the absorption coefficient is extremely low. The quantum efficiency ($\eta$) is low, too. These drawbacks are somewhat reduced by enclosing the detecting element in a highly reflective chamber to insure multiple passages of the signal photons and so increase the absorption.

The spectral response can be extended beyond 10 microns by adding impurities lying very close to the conduction or valence bands. However, you then have to cool the detector to less than liquid-nitrogen temperatures to reduce the number of free carriers generated by the interaction of lattice vibrations and these close-lying levels. At the present state of the art, this often takes bulky cryogenic equipment.

Photovoltaic grown- and diffused-junction, photoconductive high- and low-impedance, and PEM types are the five basic indium antimonide detectors in current use (see *Table*). As in all of these the photoelectric process depends on the transition of carriers from the valence bank to the conduction band, the absorption coefficient in the spectral region of sensitivity is high.

The grown-junction cell has a long and narrow sensitive area—widths of about 20-70 microns are common, with lengths varying from two to eight millimeters. Cooled to liquid-nitrogen temperatures, the diffused-

## Deriving the Theoretical Limits of IR Detector Performance

Assume that the IR detector—which may be a quantum design or any other type—has ideal response, giving a photon of a wavelength of less than $\lambda_c$ a probability of absorption, or quantum efficiency, of $\eta$, which takes into account the optical losses of the detector (see Graph). We can express the equation for the number of photons per unit area per unit time $n(\lambda)$ in the spectral region $d\lambda$ that are incident on the detector from a black background subtending $2\pi$ steradians as:

$$n(\lambda)d\lambda = \left(\frac{\lambda}{hc}\right) 2\pi c^2 h\lambda^{-5} \left(e^{hc/\lambda kT} - 1\right),$$

where $\lambda$ is the wavelength of radiation; c, the velocity of light; h, Planck's constant; k, Boltzmann's constant; and T, the absolute background temperature.

The average number of carriers (dN) generated in a detector of area A in time t is given by:

$$dN = \eta A t n(\lambda) d\lambda.$$

The incident photons don't arrive in a steady, continuous stream, but randomly, like raindrops on a roof. Their probability of arrival is described in terms of the Bose-Einstein distribution, which is included in the calculations for a mean square fluctuation of the generated carriers as:

$$\overline{\Delta N^2} = \eta\tau A \int_0^{\lambda c} n(\lambda)\left[1 + \left(e^{hc/\lambda kT} - 1\right)^{-1}\right] d\lambda$$

$$= \eta\tau A \int_0^{\lambda c} 2\pi c\lambda^{-4} \left[\frac{e^{hc/\lambda kT}}{\left(e^{hc/\lambda kT} - 1\right)^2}\right] d\lambda.$$

For a theoretical value of D*, we need an expression for the signal as well as the noise. The RMS signal can be represented by $\eta\tau N_s$, where $N_s$ is the RMS value of the signal for the number of signal photons per unit area on the detector. Now we can write the expression for D* in full as:

$$D^* = \frac{V_s/V_n}{AN_s hc/\lambda}\sqrt{A\Delta f}$$

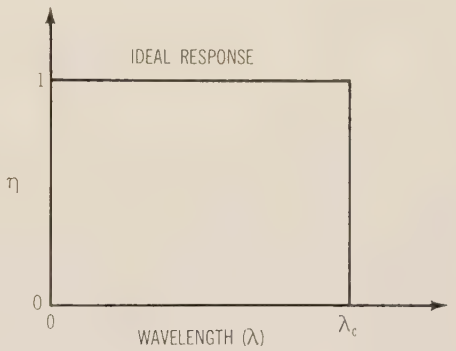
$$= \frac{\eta\tau N_s A\sqrt{A\Delta f}}{\eta\tau A\left[\int_0^{\lambda c} \lambda^{-4} \frac{e^{hc/\lambda kT}}{\left(e^{hc/\lambda kT} - 1\right)^2} d\lambda\right]^{1/2} \eta A hc/\lambda}$$

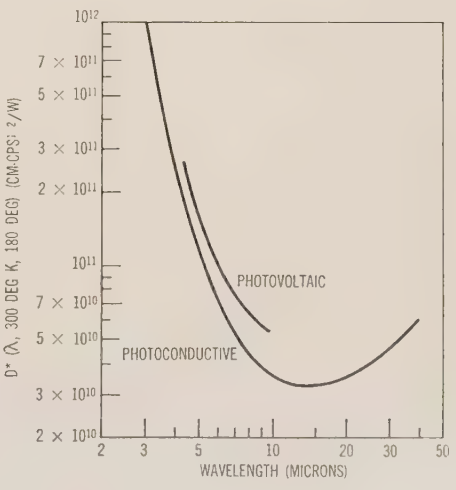
$$= \frac{\frac{\lambda}{hc}\eta}{\left[\int_0^{\lambda c} \lambda^{-4} \frac{e^{hc/\lambda kT}}{\left(e^{hc/\lambda kT} - 1\right)^2}\right]^{1/2}}$$

Where $V_s$ and $V_n$ are the signal and RMS noise voltages, respectively.

When you plot D* vs cutoff wavelength ($\lambda_c$), D* decreases rapidly at first, reaches a minimum, and then increases again (see Graph). The two terms of our equation for D* indicate that D* ought to increase linearly with $\lambda$ and non-linearly with the upper limit of the integral. However, the latter relationship is complex and actually has both an increasing and a decreasing portion.

As our plot has $\lambda_c$ and not $\lambda$ as its abscissa, its use in the evaluation of detector performance requires a comparison of detector D* at $\lambda$ with the theoretical D* for $\lambda_c$. The theoretical calculation also obviously depends on the model and the choice of cutoff.



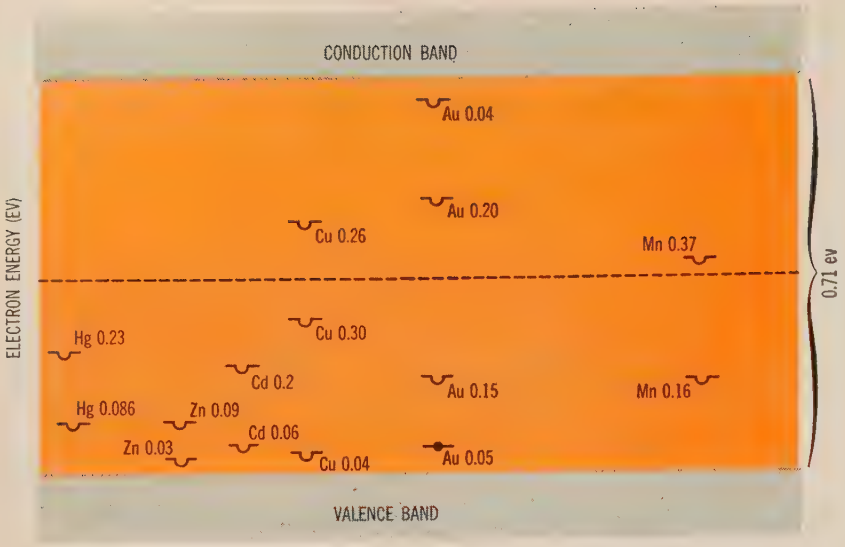
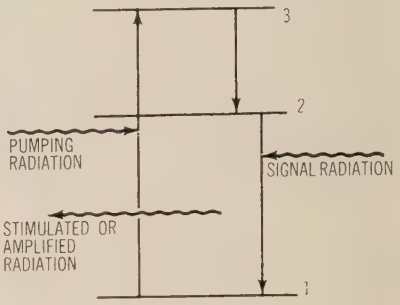



**FIGURE 2:** Energy levels of impurity atoms in germanium.

**FIGURE 3:** Quantum movement in the three-level laser.




junction detector has detectivities close to the theoretical limit. (Several manufacturers guarantee their detectors to be at least a factor or two from the theoretical limit). Photoconductive detectors can be made with either low or high impedance, which gives you some flexibility in design of the electronic signal-processing system. The PEM detector operates at room temperature.

Recent work on Ge-Si alloy detectors has shown that by varying the amounts of silicon added to germanium, you can get single crystals of the mixture with forbidden bandgaps dependent on the silicon content. By adding impurities like zinc and gold to the Ge-Si mixture, you reach ionization levels of around 0.08 ev which provide photoconductive response in the 8-13-micron region, one of the far-infrared transmission windows (see *Table*).

## The "image-position detector"

Among the more advanced experimental IR detectors, the "image-position detector" depends on the lateral photoeffect. When hole-electron pairs are generated by incident radiation on the surface of the detector, the holes move to the P-type region and the electrons to the N-type region. If the P-region is highly conductive, the holes move freely and are soon evenly distributed.

If the conductivity of the N-type region is much lower, there is much less motion, and some of the holes that have migrated far from the spot of light will cross the junction into the N-region. There is then a potential difference between these holes and the electrons that have moved only a short distance from the spot of light. Equations for current flow in two dimensions, and therefore for voltage as a function of spatial position on the detector surface, can be developed from this line of reasoning. Experimental data confirm this theory quite closely.

Electro-Optical Systems and Philco are producing detectors of this type. EOS's "radiation tracking transducer" (RTT) is a cell of uncooled silicon with spectral response to 0.9 microns. It has a time constant of six microseconds, a dynamic range of 0.7-7 K, and a flat noise spectrum from 300 to $10^4$ cps with an RMS noise voltage of 1.25 times the thermal noise. Its NEP (the light-spot's power 0.25 cm from the center that gives a S/N of unity) is about $2\times10^{-10}$ W at a bandwidth of one cps and a cell temperature of 25 deg C and it has an angular resolution of better than 0.1 second of arc. Both EOS and Philco make InSb image-position detectors with spectral response to six microns.

Radiant power also can be transduced into electric power by sensing the change in the complex dielectric constant of a photoconductor exposed to radiant energy, or power. This has been done with two photoconductors placed in the arms of a microwave cavity bridge so that one is illuminated by chopped radiation while the other serves as a reference. When you subtract the outputs, you get a signal that is essentially proportional to the input radiation and consists of a microwave carrier with an envelope frequency equal to the radiation chopping frequency. Such a system has no contact noise, no DC bias, and a time constant roughly equal to the carrier lifetime. However, it is bulky and difficult to cool.

With gold-doped germanium as the cavity detector element, NEP values of $5\times10^{-10}$ W have been reached. This is only 10 per cent of the values for conventional detectors, but then the technique of sensing changes in the complex dielectric constant is not yet fully developed nor have the current detectors using it been designed to optimize such factors as absorption of radiation. InSb is also being considered as the detector element in the microwave device.

## Lasers in IR detector design

Maser and laser concepts have been also applied to the design of IR detectors. Of course, a laser doesn't actually transduce infrared power—it amplifies the power or changes the frequency of the incident radiation. In the usual three-level laser, electrons are pumped from level 1 to level 3 by high-frequency pumping radiation (*Fig. 3*). They then fall back to level 2 and remain there in a metastable state. If the energy difference between 2 and 3 corresponds to an IR frequency, any incident IR radiation is amplified and can be detected by an IR detector.

The use of optical pumping is limited mainly by noise level and bandwidth. The limiting noise mechanism of the "iraser" is the spontaneous emission from level 2 to 1. It's not easy to calculate, but you can say that it's roughly proportional to the third power of the frequency.

Irasers, it must be assumed, are much noisier than

masers. Rough calculations show that, at radiation frequencies of $10^{-11}$ cps and a wavelength of 0.5 mm, their effective noise temperature is 28 deg K, and at $4\times10^{-14}$ cps and 0.8 mm, it is 18,000 deg K! According to more rigorous calculations, these temperatures should be lower, but probably not by several orders of magnitude.

The iraser is inherently a narrow-band device, with a spectral bandpass of about the width of the line related to the 2-1 transition. Such spectral purity can be very useful, but it's obviously not going to help you to detect power over a wide spectral band. Conceivably you could gang-tune several irasers or use some other means to increase the bandwidth—but almost invariably only at the cost of greater complexity.

These advanced techniques and others reduce the internal noise of detectors (due to lattice effects, contacts, spontaneous transitions, and other random effects of the detector material). But there is a fundamental noise that would exist even in a perfect detector: photon noise, which is due to the fact that photons arrive at the detector surface with a certain irregularity. No detector can have less noise than photon noise. Most of today's detectors come within a factor of 2-5 of the photon noise, and it's not necessarily clear that every "exotic" technique that would extend this limit would be worth the effort.

## References

*A. I. Weiman, J. Winslow, "Radiation Tracking Transducer;" Proc. 4th IRE Instr. Conf., Nov. '59.* ■ *"Infrared Sensor Developments;" Final Rep. AF 33(616)-5835, Trionics, Madison, Wis., Mar. '60.* ■ *N. Bloembergen,* Phys. Rev. *104/2, p. 324, Oct. '56.* ■ *"Literature Search No. 57: Masers;" Cal Tech, Feb. '60.* ■ *R. C. Jones,* Proc. IRE, *vol. 47, p. 1945, '59.* ■ *M. Holter, et al., "Fundamentals of Infrared Technology;" Macmillan (to be publ.).* ■ *Limperis, Wolfe,* J. Opt. Soc. Am., *vol. 51, 482A, '61. J. T. Wallmark,* Proc. IRE, *Apr. '57.* Electronics, *p. 165, July '57.* ■ *"Technical Proposal for Infrared Detector Development Programs;" Gen. Bronze, Apr. '58.* ■ *H. Steele, D. Owens, "Effects of Radiation of PbS IR Detectors and IR Optics;" Boeing, Oct. '57.* ■ *"Development of IR Guidance for Small Air-to-Air Missiles;" Avion, Q. Progr. Rep. 8.* ■ *E. W. Kutzscher,* Proc. IRE, *Sept. '59.*

# IMAGING-TUBE DETECTORS

**by Frederick A. Rosell,** Consulting Engineer,
Infrared Equipment, Light Military Electronics Dept., General Electric Co.*

POINT DETECTOR systems can generate quite acceptable thermal images. Why, therefore, do we need IR camera tubes?

The typical point detector system consists of a single sensor located on the optical axis at the focal point. Its angular resolution is defined by the dimensions of the detector and the focal length of the optics. If it is to image, the entire optical system must be made to systematically scan the view field of interest by some mechanical arrangement.

By comparison, an obvious advantage of the camera tube is its all-electronic scan. On the other hand, the field of view and the object being viewed must remain more or less stationary for at least one frame period. Furthermore, the most efficient field of view is roughly square and limited in angular extent by the wide-angle optics. Obviously, the camera tube doesn't lend itself to view fields of, say, 360 by 10 deg.

What you can do with a camera tube is to make highly efficient use of scene radiation—and that at tremendous data rates. The point detector system uses the radiation from an elemental object in the scene only while its angular-resolution element dwells on this radiation. If there are 10,000 resolution elements in the scene to be scanned in $\tau$ seconds, it collects radiation from a particular point for only $10^{-4}$ seconds.

In the camera tube, each resolution element dwells on each point of the scene for the entire time between successive readouts. During this time, most camera tubes store or integrate radiation in the form of an electronic charge. In short, the duty cycle of each resolu-

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**FIGURE 1:** Spectral quantum efficiency of copper-doped germanium for $10^{16}$ copper.

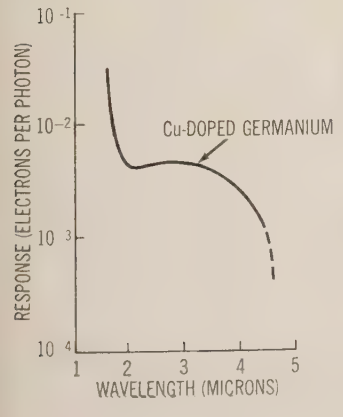
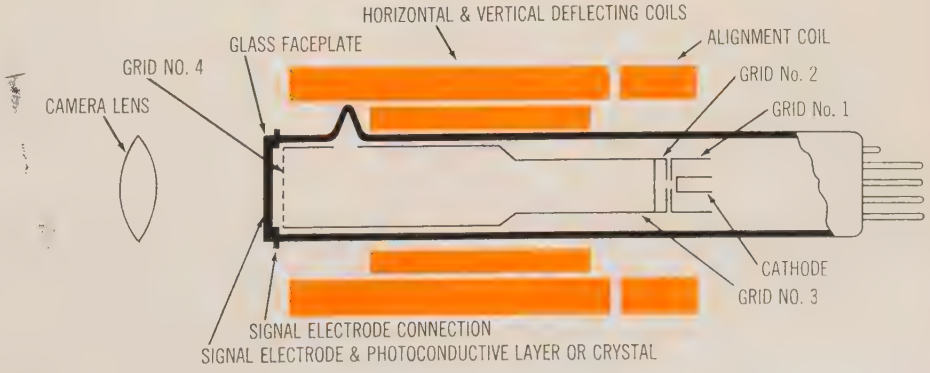



**FIGURE 2:** Typical infrared vidicon.



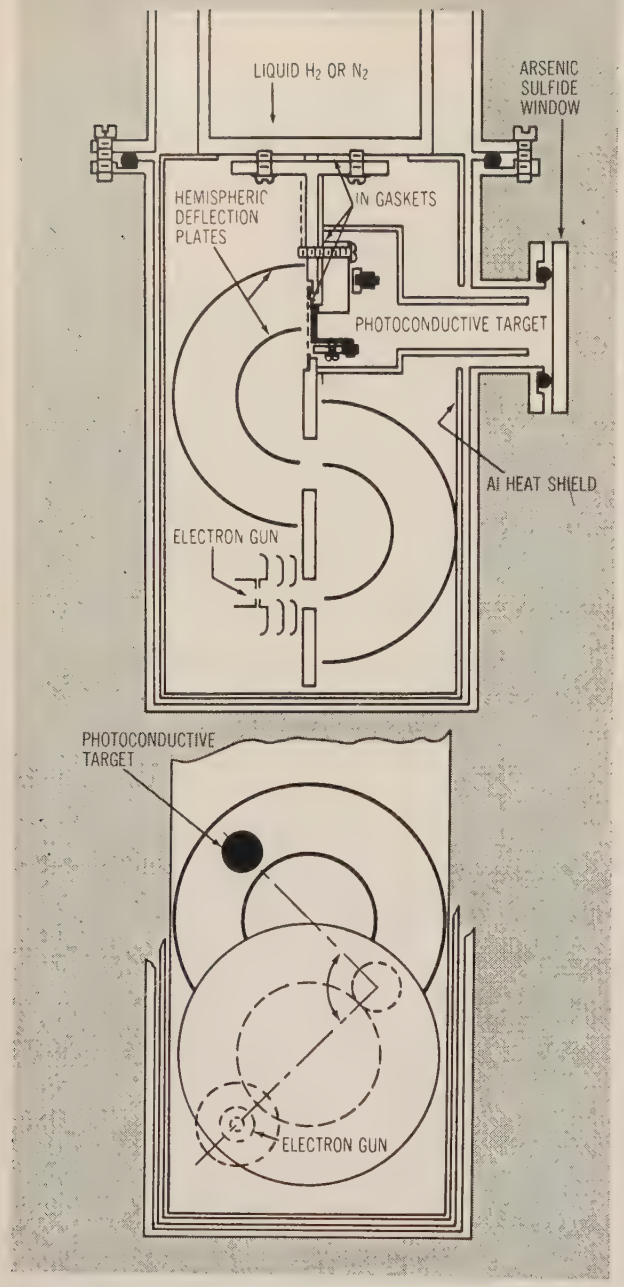



**FIGURE 3:** Demountable camera tube for studies of materials for photosensitive IR vidicon surfaces.

tion element is 100 per cent.

In an ideal camera tube, sensitivity to point images is related to the frame time, or picture rate, but is independent of the number of resolution elements. Of course, the number of resolution elements practically is limited by the finite beam size, by lateral spreading of stored charge, and so on. Still, data rates of $10^6$-$10^7$ bits per second can be obtained with very high sensitivity.

Higher absolute sensitivities can be achieved with most point detectors—but at low data rates. At lower data rates, you can also design systems with very large dynamic ranges of response—on the order of $10^4$-$10^6$. Camera tubes are limited to a range of perhaps 30-300.

High data rates are most desirable when human observers are involved, for the illusion of continuous motion in the image (corresponding to motions in the scene) can be generated without objectionable flicker. Also, the display is on a real-time basis and there is no need for an intermediate storage mechanism for the entire scene (e.g., film, storage tubes, strip charts). On the other hand, the power needed to transmit megacycles of information over appreciable distances can be overwhelming. Slow-scan techniques can reduce it somewhat, but that usually involves penalties.[1]

The main elements of an IR camera tube are the photosurface, or *target*, an electron beam gun, and the electron optics to focus and appropriately deflect the electron beam. In certain cases, you have to cool the photosurface and various parts of the tube near it.

The heart of the IR camera tube is the photo-sensitive surface. It converts incident photons to electrons. The IR photon is considerably less energetic than the visible photon, for photon energy is inversely proportional to wavelength—a fact that accounts for many of the camera tube designers' headaches.

Photoemissive materials cannot be used for camera-tube detection of IR energy, since none have been found from which electrons can be completely ejected by low-energy photons of a wave-length beyond about 1.2 microns. In the photoconductive surface, electrons are not driven from the material by photons but merely released from a trapped state to a state in which they are free to move under the influence of an electric field. This effect appears as a change in the conductivity of the material.[2]

## Thermal detectors in IR use

In the infrared, another photosurface has found application that is not ordinarily used in the visible region—the thermal detector, which usually consists of two or more materials in layers. One layer is made up of a good heat absorber, like gold black, and the other(s) of a material with a high thermal coefficient of resistance, like a thermistor. What happens to such a surface when it is irradiated is quite similar to what happens to a photoconductor when its resistance decreases, and the two surfaces can be used in much the same way.

Over the last 10 years or so, many photoconductive and thermal materials have been developed for IR point detection. Not all these materials make suitable IR camera tube targets, at least not in their conventional form.[3]

If you actually want to achieve a 100 per cent duty cycle with a camera tube, the target's resistivity must be very large—it must be a near-insulator in the dark—for the target must also serve as the charge storage medium.

Only a few materials of the many that are otherwise good IR sensors meet this requirement. In the case of photoconductors, you can only get sufficient resistivity by cryogenic cooling—to liquid-nitrogen temperatures to get sensitivity and sufficient resistivity up to five microns; to liquid-hydrogen temperatures for 20-micron response; and to liquid-helium temperatures for up to 100-microns response. The cooling requirement is a major shortcoming of photoconductive IR camera tubes not shared by thermistive types.

GE's Research Lab is studying doped germanium and silicon photocrystals as IR camera tube materials.[4] Gold-doped silicon (for wavelengths below 2.5 microns) and

(1) F. F. Martin, C. T. Sheldton, *Electronics*, June 9, '61, p. 101.
(2) R. W. Damon, J. R. Eshbach, R. W. Redington, GE Rep. 58 RL-1990, Schenectady, N.Y.
(3) Some of the results of the work on materials for camera tube targets area have been published—see G. A. Morton, S. U. Forque, *Proc. IRE*, Sep. '59, p. 1607; R. W. Redington, G. A. Saum, P. J. VanHeerden, *Trans. IRE*, July, '59, p. 297—but most is classified.
(4) Redington, VanHeerden, *J. Opt. Soc. Am.*, Oct. '59, p. 997.

copper-doped germanium (for 1-4.5 micron response) have proved suitable for camera tubes (*Fig. 1*).[5]

The germanium and silicon are thin crystal wafers ground to optical flatness. Being thicker than films, however, they have a considerably lower capacitance and therefore a correspondingly smaller time constant. Imaging tubes using these materials have very little image carry-over from frame to frame.

As photoemissive photosurfaces are not suitable for IR detection beyond 1.2 microns, we must eliminate the conventional image orthicon. However, the well-known vidicon principle can be used if materials of sufficiently high resistivity ($10^{12}$ ohm-cm) are available.[6]

In a typical vidicon, the target is mounted on or near the tube's face plate, and the front surface of the sensor is coated with a good electric conductor. An electron beam scans the back surface of the photosensor line by line. In the process, it deposits enough of an electronic charge on each resolution element to raise the potential to that of the thermionic cathode (*Fig. 2*).

Between successive passes of the beam over a resolution element, the photocathode alters its resistivity from point to point in accordance with the imaged scene. The charge pattern on the back surface is altered correspondingly by differential leakage to the electrical coating on the front surface. The electron beam current, in returning the surface-to-thermionic cathode potential, then varies from point to point and becomes the video signal current.

Other designs besides this simple vidicon are also being tried. Most of them attempt to relieve the resistivity requirement imposed by vidicon operation to make a wider range of photoconductive materials feasible as camera tube targets or to get around the theoretical sensitivity limitations imposed by the vidicon concept.[7]

Actually, it's possible to use an electron multiplier amplifier within the tube structure itself. This addition increases both signal and electron beam noise levels above the noise level of the video preamplifier. (Strictly speaking, such a device then is not a vidicon, but this fine distinction need not trouble us here).

## Hemispherical electrodes used

GE has developed a novel vidicon that uses hemispherical electrodes to produce a conventional TV scan pattern (*Fig. 3*). Both focusing and deflection are done electrostatically. Widely used for research purposes, this design has been superseded by more conventional tube structures in which thermionic and photocathodes are on the same axis. Its advantages are:

- The photoconductive target can be shielded completely from the IR radiation by the cathode of the scanning beam gun.
- The system can be cooled to very low temperatures.
- The system is easy to demount.

Noise equivalent power (NEP) is widely used to specify the performance of point detectors.[8] The analogous measure for IR camera tubes is minimum detectable temperature ($\Delta T_{min}$), which can be defined roughly as the temperature difference between an object in the scene and its background at which the object can be just barely detected. A very convenient source, or object, is the human body, since its temperature is well known. More detailed information—resolution vs. scene radiance, and the like—would of course be useful to have, but it is often hard to get.

Actually, the measurement of sensitivity in systems with wide video bandwidths is a very tricky problem even in the visible region. It is much more tricky in the infrared, where no easily constructed equivalent exists to the black and white bar chart used in the visible region and where scene radiation is a bit more difficult to control than scene illumination. The $\Delta T_{min}$ criterion does not appeal to many IR engineers, but it does, for IR camera tubes, have the advantage of accounting for the scene contrast. For instance, if your specs say that you can see a 10-deg object superimposed on a 300-deg K background, you immediately know the contrast inherent in the scene. NEP, on the other hand, ordinarily refers only to a detectable increment in energy and makes no reference to the background temperature.

However, NEP and $\Delta T_{min}$ are related.[9] Knowing one and the conditions of measurement, you can, in principle, determine the other. Promising studies are underway of methods with which to make the conversion in practice. These methods are bound to involve TV design as much as the point detector design and will require some familiarity with TV terminology, including such TV-resolution definitions as horizontal square- and sine-wave responses, effects of interlaced scan patterns, corner effects, scene contrasts, gray scales, and the like.

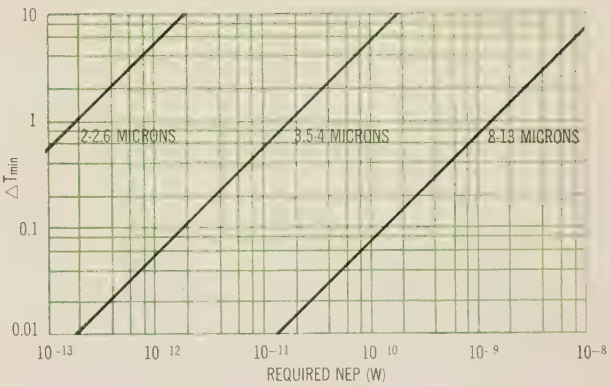



**FIGURE 4:** Minimum detectable temperature against a 300-deg-K background vs NEP as calculated by GE from test results for three spectral bands and f/1 optics, S/N at $To(\lambda)Ta(\lambda,R) = 1$ and a detector area of $2.5\times10^{-5}$ cm². On the basis of the beam-noise-limited NEP at three microns, GE found, the IR vidicon should be able to image human subjects that radiate no more than 6-8 deg over the average ambient. GE had to assume a value for the area of a resolution element because $\Delta T_{min}$ is affected by this parameter, even though NEP is not.

Like all sensors, camera tubes are limited in performance by a variety of factors. Some of the more important of these are quantum efficiency, non-uniformities of photosurfaces, stray radiation leaks, and readout beam noise.

Quantum efficiency sets a fundamental limit on the performance of the IR camera tube. The conversion efficiency of the very best photosurfaces in the visible region averages about $10^{-1}$ electrons per photon. In the

(5) M. E. Seymour, *Electronic Eq. Engrg.*, May '61.
(6) P. K. Weimer, Forque, R. R. Goodrich, *Electronics*, May '50, p. 70.
(7) Damon et al., *op. cit.*
(8) R. C. Jones, *Proc. IRE*, Sep. '59, p. 1495.
(9) Rosell, GE Rep. R60 SD 462, Nov. '60, Philadelphia.

middle IR band, it may be more like $10^{-2}$-$10^{-4}$ and in the far IR band the figures may be $10^{-5}$-$10^{-7}$. You have some control over spectral quantum efficiency, but not much.

Non-uniformities in photosurfaces may be due to lack of cleanliness in preparation, variation in film thickness, variations in doping or sensitization processes, impurities in the raw material, etc. Faulty beam landing—which is not a defect of the photosurface material—results in an apparent variation in sensitivity across the surface. Whatever the defect, in the infrared it can be quite serious even though small—because of the high background levels of the expected signals.

Stray radiation leaks cause a lot of trouble in IR imaging tubes. In the visible spectrum, you merely have to make sure that the camera tube's enclosure is light-tight and that the optical paths are free from reflecting surfaces. The IR tube must be not only light-tight but also radiation-tight. If you are detecting 300-deg K objects, for instance, it would never do to flood the photosurface with 300-deg K wall radiation. Cold shields are an obvious remedy for this problem. Another radiation problem is posed by the thermionic cathode and its hot aperture plate, both excellent sources of IR radiation.

Vidicons are definitely performance-limited by readout beam noise. Though the average number of electrons striking any resolution element of the scanned surface in one pass of the readout beam fluctuates, the resultant noise can easily be calculated so long as you know the bandwidth of the system and the average beam current.

As the expected signal current is the product of the number of resolution elements, the irradiation of each, and the quantum efficiency, you can determine the S/N ratio. Alternatively, if you have the various terms in their literal form and make S/N unity, you can derive NEP for one resolution element.

For point targets, a beam-noise-limited NEP does not depend on the number of resolution elements or the bandwidth of the system, except as bandwidth is related to the frame time. Computation shows that an NEP of $10^{-13}$ per resolution element ought to be obtainable at W three microns, assuming a quantum efficiency of $10^{-3}$ electrons per photon, a 1/30-sec frame time, and a beam current set at 100 times the minimum detectable signal current. Such an NEP can be converted to $\Delta T_{min}$, though the necessary calculations are somewhat involved (*Fig. 4*).

As systems using point detectors can differentiate the output of the detector, they need not be contrast-limited. Only incremental energy differences between objects and their backgrounds are displayed, the DC background radiance being removed by a capacitor. The detector itself in most cases is relatively immune to the background level, or at least can tolerate rather wide variations.

In the camera tube, the electrons, due to background that leak through to the front surface of the target must be replaced by the electron beam. Limits can be imposed either by the capacity of the beam to replace these electrons or by the beam-generated noise. The beam current is ordinarily set at a fixed value and at a high enough level to discharge highlights in either the object or the background. However, as the noise level of the beam curent is proportional to its magnitude, threshold, or "lowlight", performance is limited by the noise of the highlight level. In effect, therefore, the IR vidicon may be contrast-limited.

Conventional broadcast TV, for which scene and lighting usually are carefully arranged, has accustomed us to contrasts near unity. In the imaging of terrain, however, most objects differ only slightly from ambient temperatures, and low scene contrast is the normal situation. Contrast is a function of the spectral bandpass, the temperature difference between an object and its surroundings, and the absolute temperature of the background. For small temperature differences ($\Delta T$ above a background at T deg K), the contrast of an object can be expressed by:

$$C = 1.44 \times 10^5 \Delta T/(\lambda T^2).$$

Assuming $\Delta T = 1$ deg K, T = 300 deg K, and $C = 0.16/\lambda$, the object-background contrast is four per cent at four microns, and only 1.6 per cent at 10 microns.

Even under good lighting conditions, a reduction in contrast is accompanied by a reduction in the human eye's resolving power. A commonly accepted measure of human visual acuity is one minute of arc, but this holds only for objects of near-unity contrast. At one per cent contrast, an observable object must subtend about 30 minutes of arc.[10] On a TV monitor screen that is 12 in. high and has a 400-line presentation, the width of a line subtends about one minute if the observer is 8½ feet away. At 2-4 ft, the subtense of a line width is 2-4 minutes. For objects of this size, contrasts of 7-20 per cent are needed.

To predict the performance of an IR camera tube, you must consider the spectral bandpass. Two spectral bands are of special interest: the middle IR from one to about five microns and the far IR, which, for military use, is the 8-13-micron band. These two bands correspond roughly to the IR windows in the atmosphere.

## Radiation leaks cause trouble

Among point detectors, the photoconductor traditionally has predominated at wavelengths shorter than five microns, while the thermistor detectors are more attractive for the longer wavelengths. Whether used as point detectors or camera tube targets, photoconductors in the 3-5 micron band generally are about 100 times more sensitive than thermistor devices. Even for the detection of objects near 300 deg K, you can expect thermistive devices in the 8-13-micron band to give about the same performance as does the photoconductor in the 3-5-micron band. For detecting objects at appreciably more than 300 deg K, the photoconductive camera tube is expected to lead the field.

Photoconductors are, of course, also available for the far IR, but here their sensitivity advantage is not so pronounced. The great advantage of the thermistor, of course, is that it operates without cooling. Photoconductors need lower and lower temperatures as they come up against the longer wavelengths, so the price and bulk of cooling may become prohibitive in the absence of a significant sensitivity advantage.

The IR camera tube will undoubtedly provide new answers to several old problems. For instance, it can see through many materials that are opaque to visible light and observe stress patterns in these materials.

For satellites, an IR-vidicon horizon sensor with no moving parts, high resolution, and fast response has many advantages, IR mapping of planets and star sighting are also distinct possibilities. Applications in surveillance and terminal guidance become more attractive as aircraft reach hypersonic speeds and in view of the high radiation levels of missile plumes and re-entry vehicles.

(10) H. R. Blackwell, *J. Opt. Soc. Am.*, vol. 31, p. 635, '46.

# THERMAL DETECTORS

**by E. M. Wormser and Russel De Waard,** Vice-President & Technical Director & Head, Applied Physics Section, Barnes Engineering Co.*

WHEN YOU ARE comparing photodetectors and thermal detectors, a basic point to keep in mind is that photodetectors have high but non-uniform sensitivity in certain wavelength regions below 40 microns. The photodetectors that are most sensitive to radiation from targets at temperatures below incandescense must be cooled to liquid-nitrogen temperatures or even lower ones.

Thermal detectors, on the other hand, don't require cooling, and their sensitivity is essentially constant over a broad band from the ultraviolet through the far infrared. As their output is produced by the heating effect of the incident IR radiation, you can look on them as power detectors whose output is proportional to the total energy of the absorbed radiation.

Thermal detectors can safely be said to surpass photodetectors where constant response to different wavelengths is most desirable, as in instrumentation for analyzing the spectral characteristics of emitted, transmitted, or reflected IR radiation. Also, thermal detectors are more sensitive below incandescence than are uncooled photodetectors. In the target-temperature region from below ambient to incandescence, photodetectors cooled by circulating fluids have the highest sensitivity. Nevertheless, thermal detectors are often the better choice, because they do not require cooling systems.

About the only practical thermal detector that produces a useful signal by mechanical or optical effects is the pneumatic type. In its simplest form, it consists of a small, gas-filled chamber with an IR-transmitting window. Some means is provided for absorbing the radiation admitted to the chamber and for turning the pressure change in the chamber into a measurable signal output.

In Eppley Labs' Golay-type pneumatic cell, radiation is admitted through the infrared window (NaCl, KBr, KRS-5, and others) and absorbed by a thin-foil, blackened receiver that makes up one end of a small-gas-filled chamber. Pressure changes distend a small, flexible mirror at the other end of the chamber. The extent of the distortion is detected by a photocell that receives the light reflected by the mirror. The optical overlapping of grid lines suitably modulates the photocell input.

The entire detector assembly, including light amplifier and photocell, measures roughly 1.5×3×8 in. For spectrometric applications, 10-cps chopping is suggested as best for a nominal detector time constant of about 15 millisec. The standard receiver element has a $\frac{3}{32}$-in.-diameter absorbing disk, though you can specify other sizes and shapes. Time constants range from about two to 30 millisec. The noise equivalent input (NEP) reportedly is as low as $6\times10^{-11}$ W (when you use a special synchronous-rectifier-type amplifier).

In Patterson-Moos' pneumatic cell, the gas in the cell cavity absorbs radiation, producing pressure rise in the chamber. By using gases with selective absorption bands, you can restrict detection to preselected wavelength intervals.

The overall size of the pneumatic cell depends largely on the size of the sensing area, or entrance port. A cell with a 20mm² sensitive area typically is about one inch long and 0.5 in. in diameter. The metal cell housing usually is hermetically sealed with a sapphire or germanium window.

A capacitive or condenser-type output provides electric signals. As their response time is fast, these cells can be used with a radiation chopper at up to 50 cps (or at higher frequencies with some loss in responsivity).

Thermoelectric detectors are based upon the Seebeck effect—voltages are generated across a heated junction of dissimilar metals. When the junction is blackened and

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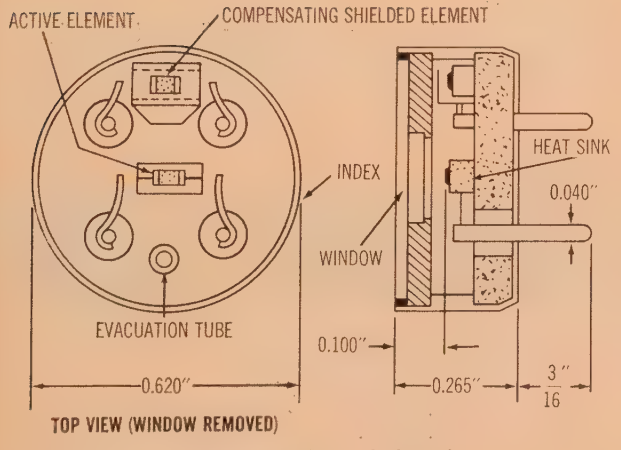


**FIGURE 1:** Standard thermistor bolometer.

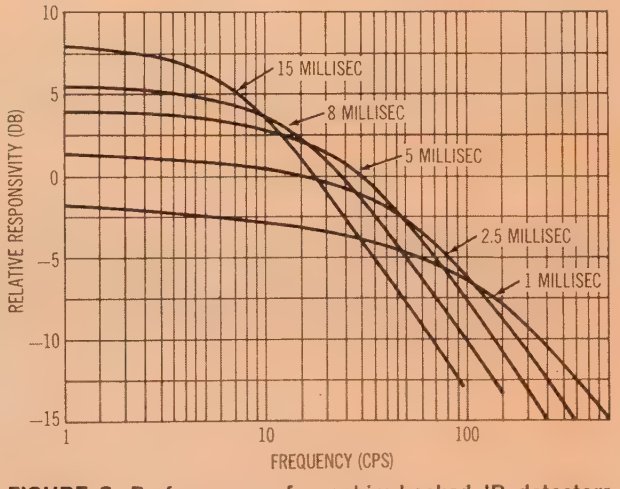


**FIGURE 2:** Performance of sapphire-backed IR detectors at various time constants ($\tau$), an NEP of $10^{-8}\sqrt{A}/\tau$ W, and a noise bandwidth of $1000/(4\tau)$ cps, where A is area (in mm²).

placed at the focus of a suitable optical system, the thermocouple acts as a radiation detector. The trends in radiation thermocouple design point to a combination of fast response time and precise control of the sensitive area.

## Fast response and AC operation

Perkin-Elmer's pin-type thermocouple, for instance, is designed for fast response and AC operation in IR spectrophotometric instrumentation. The receiver area is proportioned to match, as nearly as possible, the 2×0.2-mm image of the monochromator exit slit. The receiver itself is a thin gold-foil strip coated with gold black and welded at its ends onto relatively massive, wedge-tipped pins of special semiconducting thermoelectric materials. The combination of the low thermal mass of the receiver strip, high thermoelectric power, and the thermal conductivity in the junction materials gives you both fast response and high responsivity (see *Table*). The evacuated detector is normally housed behind a suitable window at the end of a stem-type mounting, which minimizes obscuration when the detector is located at the focal point of a fast mirror.

Farrand Optical's Hornig-type thermocouple—now available from Reeder—uses a thin, low-heat-capacity, blackened gold-foil receiver joined by short, fine thermoelectric wires whose combined heat capacity is small in comparison with the foil receiver area. This detector is operated in an evacuated, stem-type housing and used chiefly in spectroscopic instruments.

A wide range of receiver sizes and types of mountings for spectrometric instruments is covered by the thermocouples made by Reeder. This company also has designed a number of special, large thermopiles for lab use, is developing spectrally selective thermopiles, and has plans for detectors extending into the 50-100-micron region. Reeder detectors use both pin-type (Schwartz) and wire-type (Hornig) designs and combinations of the two. Their materials used include bismuth and bismuth-tellurium alloys. High responsivity is reported for these detectors, with noise outputs held substantially at the level of the Johnson noise of the thermocouple resistance.

Both metallic and thermistor bolometer thermal detectors basically consist of a thin strip of blackened material that undergoes a large change of resistance when its temperature is changed by the absorbed radiation. Typical sensitive materials include metals like nickel and platinum and semiconductors like sintered mixtures of manganese, nickel, and cobalt oxides. To detect the change in resistance, a DC polarizing voltage is applied across the resistance element. The resistance change then modulates this potential.

## Characteristics of Available Thermal IR Detectors

### Thermoelectric Detectors

| | Pin Thermocouple (Perkin-Elmer) | Hornig Thermocouple |
|---|---|---|
| Receiver area (mm) | 2 × 0.2 | 0.75 × 0.75 |
| DC resistance (ohms) | 10 | 6-10 |
| Responsivity (V/W) | 2 @ 13-cps chopping | 7-10 (abs.), 3-4 @ 5-cps chopping, 1.5-2.5 @ 10-cps chopping |
| Noise (V RMS in 1-cps bandwidth) | 4-6 × $10^{-10}$ (Johnson noise of DC resistance to 1.5 times Johnson noise) | 5 × $10^{-10}$ (approx. Johnson noise of DC resistance) |
| Noise equivalent power (W per 1-cps bandwidth) | 2-3 × $10^{-10}$ | 2-3 × $10^{-10}$ @ 10-cps chopping |
| Long-wavelength response (microns) | | uniform to 25 with KCl window |

### Metal Bolometers

| | Platinum-Strip Bolometer (Baird-Atomic) | Heimann Vacuum Bolometer (Physikalisch-Technische, Werkstätten, Wiesbaden, West Germany) |
|---|---|---|
| Receiver area (mm) | 7 × 0.3 | 0.6 × 0.6 |
| Resistance (ohms) | 40 | 2000 |
| Responsivity (V RMS peak-to-peak per W) | 4 | |
| Chopping frequency (cps) | 10 | 20 |
| Bias (V) | | 2 |
| Time constant (millisec) | 16 | 5 |

Bolometer elements made of thin strips of metal undergo a change in resistance of about 0.3-0.4 per cent per degree C of temperature rise. To make metallic sensing elements both sensitive and fast in response, you have to minimize their heat capacity per unit of area. In other words, the sensing strip must be kept very thin (for instance, by rolling small-diameter wires into strips less than one micron thick). Other physical parameters that determine the radiation-detecting characteristics of such elements include the heat conductivity of the element itself, the thermal conduction losses from the element, and the radiation exchange. A typical bolometer using such a metallic element has a resistance of 20 ohms, a time constant of four milliseconds, a responsivity of one volt per watt, and a noise equal to the Johnson noise of the element's resistance.

Thin films have also been made by vacuum evaporating nickel and bismuth into layers as thin as 500 A. Metallic bolometer elements usually are blackened by evaporating onto them thin layers of gold or platinum black, which produce good radiation absorption out to 15 microns.

At present, metal bolometers are available only in a limited range of sizes and models. A good example is Baird-Atomic's AT3 platinum-strip bolometer, which uses evaporated gold blackening and is designed primarily for spectro-radiometry. It is housed in an evacu-

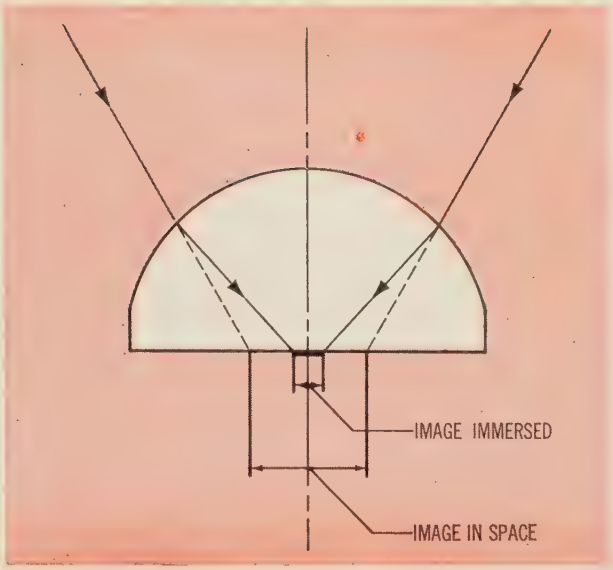


**FIGURE 3:** In a thermistor using immersed optics and a germanium lens, the immersed image has only one-fourth the linear dimensions of the image in space. The detectivity of this thermistor approximately equals the reciprocal of $\sqrt{A}$, where A is the detector area.

**Metal Bolometers**

| | Platinum-Strip Bolometer (Baird-Atomic) | Helmann Vacuum Bolometer (Physikalisch-Technische, Werkstätten, Wiesbaden, West Germany) |
|---|---|---|
| Noise equivalent power (W) | $10^{-9}$ for 10-cps bandwidth | $10^{-9}$ for approx. 1-electric bandwidth |
| Wavelength range (microns) | 1-26 (uniform response) | 10-1000 (depending on window) |
| Window | usually AgCl | KBr (to 25 microns), KRS-5 (to 40 microns), quartz (50-1000 microns) |

**Thermistor Bolometers**

| | Standard Thermistor Detector (Barnes) | Ge-Immersed Detector (Barnes) |
|---|---|---|
| Ambient resistance | 1-5 megohms | 200 K & 2 megohms in square sizes; down to 30 K in long, narrow aspect |
| Flake Size (mm) | 0.1 × 0.1, 0.3 × 0.3, 0.5 × 0.5, 1.0 × 1.0, 1.5 × 1.5, 2.0 × 2.0, 2.5 × 2.5, 2.5 × 2.5 side by side | 0.1 × 0.1, 0.5 × 0.5, 1.0 × 1.0 (others to specs) |
| Time Constant (millisec) | 1-16 | 2-16 |
| Responsivity (V/W, active flake of 2-millisec, 2-megohm detector @ 80-cps chopping) | 1300 (0.5 × 0.5 mm detector area) | 10,000 (0.1 × 0.1-mm detector area) |
| Noise equivalent power (W in 1-cps bandwidth) | $2.3 \times 10^{-10}$ | $3.5 \times 10^{-11}$ |
| Windows | KRS-5 (0.6-35 microns), AgCl, (2-15 microns), sapphire, quartz, coated Ge, etc. | coated hemispheric or hyper-hemispheric Ge lens |

ated steel mounting that usually has a silver chloride window. With a high-grain transformer and narrow-band amplifier, its detectivity is limited by Johnson noise.

The Heimann vacuum bolometer, made by West Germany's Physikalisch-Technische Werkstätten, uses a very thin metal coating deposited on a thin membrane. The mirror-like metal film receiver is supported by the membrane in a tubular evacuated capsule that is 4.5 in. long, 0.75 in. in diameter, and closed with an IR window. The unblackened receiver has increasingly better absorption (and hence response) from about 15-20 microns out to 1000. Response falls off at wavelengths below 15 microns. For ambient-temperature compensation, a metal film that cannot see the window is attached to the back of the receiver.

Thermistor bolometer elements made of thin layers of sintered semiconductor oxides undergo a decrease in resistance of about four per cent per degree C of temperature rise. With a resistance change that is generally around 10 times higher than that of metal bolometers, thermistor bolometers tend to have significally higher responsivity. Furthermore, the thermistor material itself is a good absorber of far-IR radiation. Blackening is still used, however, in order to maximize absorption.

In a typical commercial thermistor bolometer, two closely matched thermistor flakes are mounted on a base of high thermal and low electric conductivity (*Fig. 1*). The active element is exposed to radiation, while the compensating element is shielded. The two elements are connected by a bridge circuit and are equally and oppositely biased. The signal output is at the junction between the flakes, which is near ground potential to reduce noise and microphonics. Ambient-temperature changes produce no signal output, but chopped radiation on the active element produces an AC signal.

Modern high-quality thermistor detectors cover time constants from less than one millisecond to the order of 15 millisec (*Fig. 2*). This range is typical of Class II detectors as defined by Jones,* and as these detectors all have the same quality, you can trade responsivity for time constant and choose the detector best suited to the chopping speed you need.

Detectors of this type are suitable for radiometers, spectrometers and other lab equipment, as well as for missile range instrumentation and IR signature studies.

## Detectivity upped by immersion

Extensive efforts have been made to increase the detectivity of thermistor bolometers. The reason for this is that there are limits to the optical gain you can get with IR optics—there comes a point when still larger collecting mirrors or lenses are simply no longer practical.

Optical immersion appears to be the answer to this problem. It provides greater sensitivity because the detectivity of thermistor flakes (and other types of detectors) increases with decreasing receiver area. To take advantage of this characteristic, a reduced-area thermistor element is immersed at the rear of a germanium lens that focuses the incoming radiation upon this smaller detector (*Fig. 3*). Germanium is preferable to other materials because of its high index of refraction, its broad spectral bandpass characteristics (2-20 microns), its good thermal properties, and because it is well suited to the manufacturing process.

The image at the plane face of the germanium ele-

* R. C. Jones, "Phenomenological Description of the Response and Detecting Ability of Radiation Detectors"; *Proc. IRE*, 47/9, Sep. '59.

## IR detectors

| Manufacturer | Type | Spectral Region (microns) |
|---|---|---|
| Baird-Atomic, Inc., 33 University Rd., Cambridge, Mass. | thermal<br>thermal imaging | 1-26<br>UV-50 (salt window) |
| Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn. | thermistor-bolometer thermal (controlled-area type) | unimmersed: UV-50 (without windows); immersed: depends on window |
| Block Associates, Inc., 385 Putnam Ave., Cambridge 39, Mass. | quantum<br>quantum | 1-7.5<br>1-7.0 |
| Bulova Research & Development Laboratory, 62-10 Woodside Ave., Woodside, N. Y. | PbS, quantum | 1-5 (2 peak) |
| Cetron Electronics Corp., 715 Hamilton St., Geneva, Ill. | area | 0.5-2.0 (50% pts.) |
| Comptometer Corp., Radiation Electronics Div., 5600 W. Jarvis, Chicago 48, Ill. | InSb, quantum<br>InSb, quantum<br>InSb, quantum<br>InSb, quantum | 2-7<br>2-6<br>2-5.5<br>2-5.5 |
| Eastman Kodak Co., 343 State St., Rochester 4, N. Y. | thin-film area, quantum<br>thin-film area, quantum<br>thin-film area, quantum<br>thin-film area, quantum<br>thin-film area, quantum<br>thin-film area, quantum<br>thin-film area, quantum<br>thin-film area, quantum<br>single crystal, quantum<br>single crystal, quantum | UV-3.2<br>UV-3.6<br>UV-4.5<br>UV-4.5<br>UV-5.0<br>UV-4.5<br>UV-5.0<br>UV-6.0<br>1-28<br>1-22 |
| The Eppley Laboratory, Inc., 12 Sheffield Ave., Newport, R. I. | thermal | UV-mm |
| General Bronze Corp., Electronics Div., 711 Stewart Ave., Garden City, N. Y. | microwave | 1-5 (depending on semiconductor) |
| General Electric Co., Light Military Electronics Dept., Ithaca, N. Y. | photo-imaging tube | 1-4.5 |
| General Electrodynamics Corp., Garland, Texas | thermal, camera tube | middle to far IR |
| General Precision Inc., Librascope Div., 808 Western Ave., Glendale 1, Calif. | quantum<br>quantum | 2-5<br>2-5 |
| Hughes Aircraft Co., Santa Barbara Research Center, Goleta, Calif. | quantum<br>quantum<br>quantum<br>quantum<br>quantum<br>quantum | 3-5<br>3-5<br>3-5<br>3-4.5<br>3-4<br>2-28 |

# for aerospace applications

| Materials & Principle of Operation | Operating Temperature | Applications | Status & Remarks |
|---|---|---|---|
| Pt strip, bolometer (Mod AT3) | ambient | tracking, radiometer, sun tracker | production |
| evaporagraph; gives integrated two-dimensional image; time constant ~20 sec | ambient | ground-radiance mapping, surveillance | production |
| sintered metallic-oxide semiconductors (Mn, N, Co oxides) with large negative temperature coefficients; bolometer | unimmersed: —50° to 80° C immersed: —50° to 50° C | any application requiring uniform spectral response, minimum size & weight (no cooling system needed); unimmersed types used in ground-based systems; immersed types for airborne and space use | available; R&D being done to extend upper temperature limits of immersed detectors; also working on spectrally selective and printed bolometer types |
| InSb, photoconductive | 0°—40° C | lasers, interferometers, spectrometers | production |
| InSb, photoconductive (thermoelectrically cooled) | 40° K | intrusion detectors, image systems | pilot production |
| glass substrate polybutyl, methocrylate, photoconductive | ambient | missile detection; early warning; spectrometers; target homing (Sidewinder) | production |
| photoconductive cell, evaporated lead sulfide | 130° F | IR- & visible-light-sensitive controls | available from stock |
| photoelectromagnetic; photo absorption results in excess carriers, directed in bulk to cause a current flow | 25° C | all types of temperature measurement for high heat processes, research instruments, military detection instruments, etc. | production; advanced types in R&D |
| photoconductive resistance of cell changes as direct result of photo absorption | —78° C | | |
| | —196° C | | |
| photovoltaic, InSb | —196° C | | |
| PbS (chemical) | 25° C | UV detectors, search, track, fuze, photometry, radiometry, intrusion devices, data readout | production |
| PbS (chemical) | —78° C | | production |
| modified PbS (chemical) | —196° C | | production |
| PbSe (chemical) | 25°C | | production |
| PbSe (chemical) | —78° C | | production |
| PbSe (chemical) | 25° C | | production |
| PbSe (chemical) | —78° C | | production |
| PbSe (chemical) | 196° C | | production |
| Cu-doped Ge | —268° C | | experimental |
| Cd-doped Ge | —253° C | | experimental |
| thermocouple & golay pneumatic | variable | spectroscopy; relative & absolute measurement of thermal radiation | production |
| photoconductive, microwave electromagnetic field substituted for conventional DC bias of semiconductor; tuned microwave cavity containing photosensitive semiconductor; IR energy enters cavity through small aperture, illuminates semiconductor, cavity is detuned; Ge, Au-doped Ge, InSb | 77° K | recon, surveillance, detection, track; missile & airborne guidance communications; remote temperature monitor & survey; lab instrumentation, IR analyzers | NEP of $1.2 \times 10^{-11}$ W with intrinsic Ge semiconductor; other materials being tested; miniaturization of detector & microwave generator being studied. |
| Cu-doped Ge photoconductive (vidicon), electrostatic deflection of electron beam across photosurface | 77° K | surveillance, ballistic missile track, guidance, search-track | developmental |
| thermistor, thermal imaging | ambient | high-sensitivity far-IR surveillance, mapping | limited development |
| PbSe, photoconductive, D* (500, 1000, 1)=$10^8$ (cm-cps/W)$^{1/2}$ | ambient | supplied in dewars or for packaging by customer | developmental |
| PbSe, photoconductive, D* (500, 1000, 1)=2-5x$10^9$ (cm-cps/W)$^{1/2}$ | 77° K | | small-quantity production |
| PbSe (isolated element), photoconductive | —196° C | airborne & space systems | production |
| PbSe (element in vacuum) | —196° C | | production |
| PbSe, photoconductive | —78° C | | production |
| PbSe, photoconductive | ambient | | production |
| PbSe | —196° C | | production |
| Cu-doped Ge, photoconductive | 4.2° K | airborne search & track systems | production; 30° or 60° peak FOV |

ment is only one-fourth in linear dimensions of the image in space, and the area of the receiver therefore can be one-sixteenth of what it would be otherwise. As thermistor detectivity varies inversely with the square root of thermistor area, you gain a fourfold increase in detectivity. With proper matching of detector lens and optical system, an immersed detector can have the same sensitivity as an unimmersed one that is ten times larger.

In certain cases, systems can be designed to detect targets that emit radiation in a specific narrow or broad band of wavelengths. Any radiation that such a detector receives at other wavelengths then merely masks the desired signal. The undesired wavelengths can sometimes be absorbed by filters placed in the optical path, but often these filters also absorb large portions of the desired wavelengths.

In any case, filters with the necessary bandpass characteristics may not be available. A better solution is to use a thermistor detector sensitive only to the desired wavelength band.

## Thermistor element is made "blind"

Such a detector can be produced by making the thermistor element completely reflective by means of an evaporated gold overlay. To get spectral selection, this blind thermistor element is then coated with a material with the appropriate absorption spectra. Both organic films and powdered slurries of inorganic compounds have been used as coatings, or sensitizers. You can measure the radiant energy from a material by coating the detector with a thin film of the same material. In this case, the detector senses only the radiation emitted in characteristic absorption bands.

With an inorganic mineral as the sensitizer, a detector has been made sensitive from 14-16 microns—the strong $CO_2$ absorption band. Everywhere else in the infrared this detector is essentially insensitive.

This sensitizing technique can be combined with optical immersion by depositing an IR-transparent detector element on the rear surface of a lens made of germanium or some other IR-transmitting material. When suitable absorbing materials are then deposited on the exposed sensitive area, the detector can be made sensitive to the desired band of radiation. Like most spectrally selective designs, this detector is in an early developmental stage.

All the thermistor detectors we have discussed so far are high-impedance units meant to be used with vacuum-tube preamplifier circuits. To meet tighter size and weight specs, we now need thermistor bolometers that can be coupled directly with transistor circuits. For such applications, theory and experiments show that the optimum resistance of the thermistor should be 50 K.

Low-impedance thermistors have already been produced and matched to transistorized preamplifiers. Generally it has proved possible to come within six decibels of the theoretical Johnson noise of the bolometer resistance.

Thermistor-detector elements and their connecting leads have been printed directly on ceramic bases. Small single detectors, linear arrays, and 100-element mosaics have been produced in this fashion at Barnes. Linear arrays are useful when large areas must be scanned in a minimum time, while mosaics show great promise for IR imaging at long wavelengths.

For the present, the time constant of the printed detectors is limited to a nominal two milliseconds. As these thermistors use no organic cements, they offer great advantages for use at high ambient temperatures.

## IR detectors

| Manufacturer | Type | Spectral Region (microns) |
|---|---|---|
| Hughes (cont.) | quantum | 4.5-8 |
| Infrared Industries, Inc., Box 42, Waltham, Mass. | chemical | 0.7-4.5 |
| ITT Laboratories, 3700 East Pontiac St., Ft. Wayne, Ind. | quantum (point)<br>quantum (point) | 1.6<br>1-6 |
| The Martin Co., Electronics Div., Baltimore 3, Md. | single-crystal photoconductors<br>single-crystal photoconductors<br>single-crystal photoconductors<br>single-crystal photoconductors<br>single-crystal photoconductors | 2-9<br>2-40<br>2-30<br>2-35<br>2-13 |
| Micro Systems Inc., 319 Agostino Rd., San Gabriel, Calif. | radiation tracking XY20 (single element), photovoltaic cell | 0.5-1.1, 0.8 peak |
| Minneapolis-Honeywell Regulator Co., Aeronautical Div., 1915 Armacost Ave., Los Angeles 25, Calif. | quantum<br>quantum | 1-7 (6.2 peak)<br>1-5 (5 peak) |
| Philco Corp., Lansdale Div., Church Rd., Lansdale, Pa. | quantum point detector | 1-5, peak 1.7<br>2-9 |
| Polan Industries, Inc., 220 Eighth St., Huntington, W. Va. | quantum<br>thermal resistance | $\leq 6$<br>$\geq 1.7$ |
| Radio Corp. of America, RCA Electron Tube Div., Harrison, N. J. | quantum<br>quantum<br>IR camera tube<br>phototube (RCA 7102)<br>photocell (RCA 7223)<br>image converter (RCA 6032, 6914, 6929) | 1.9-9<br>9-14<br>1-5<br>S-1<br>S-14<br>S-1 |
| Raytheon Co., Spencer Lab., Burlington, Mass. | quantum, area<br>quantum, area<br>quantum, area<br>quantum, area<br>quantum, area | 1-9<br>1-16<br>1-25<br>1-30<br>1-6 |
| Servo Corp. of America, Hicksville, N. Y. | thermal | UV-1000 |
| Texas Instruments, Inc., Materials & Sensors Dept., Dallas 22, Texas | quantum<br>quantum<br>quantum<br>quantum<br>quantum | 1-5<br>1-5<br>1-28<br>1-3.5<br>0.4-1.0 |
| Varo Inc., 2201 Walnut St., Garland, Texas | quantum, area | 0.7-1.2 |
| Westinghouse Electric Corp., Box 2278, Pittsburgh 30, Pa. | thermistor<br>thermal imaging | middle to far IR(?)<br>1-14 |

# for aerospace applications

| Materials & Principle of Operation | Operating Temperature | Applications | Status & Remarks |
|---|---|---|---|
| Au-doped Ge, photoconductive | —196° C | ground & airborne surveillance | production; high sensitivity in 8 micron region if operated at ~60° K; S/N ratio flat out to 1 mc |
| PbS, photoconductive | 100° to —196° C | guidance & tracking, temperature-seeking | production (off shelf) "most sensitive detector type in its spectral region" |
| PbTe, photoconductive | —196° C | search & track sets | production |
| InSb, photovoltaic | —196° C | search & track sets | production |
| Au-doped Ge | 77° K | ground mapping, color discrimination | available |
| Zn-doped Ge | 8° K | outer & near atmospheric target detection; ASW, AICBM, anti-satellite detection | available |
| Cu-doped Ge | 13° K | | |
| Cd-doped Ge | 28° K | outer & near atmospheric target detection; ASW, AICBM, anti-satellite detection; air-to-ground, ground-to-air | available |
| Hg-doped Ge | 38° K | | |
| Si PN photovoltaic device uses lateral photo currents flowing parallel to junction | —40° to 100° C | solar, lunar, missile track; automatic high-speed electronic auto-collimator readout; gyro pickoff | production |
| single-crystal InSb; photoelectro-magnetic; time constant <1 usec | 190° F (max) | remote measurement of temperature of stationary & rapidly moving objects or of rapidly changing temperatures; measures relatively cool targets (100° F) & targets at >2500° C | production |
| single-crystal InSb; photoconductive; D* in $10^{10}$-power area | 77° K | search, mapping, surveillance systems | production |
| N-type Ge, photoconductive | 77° K | guidance, search-track | production |
| P-type Ge, photoconductive | 77° K | guidance, search-track, early warning, recon, thermal mapping | production |
| InSb | liquid $N_2$ | industrial control, background measurement of radiation, mapping; high-speed detection | available; detects from $10^{-13}$ W at spectral peak; time constant <2.0 usec |
| thermistor bolometer | ambient | detection & seeking devices | two surfaces; Ge windows coated for anti-reflection |
| Ge:Au, photoconductive | 78° K | | production |
| Ge:Si, impurity-activated with Zn ions | 48° K | | development of Ge:Si types |
| vidicon | | probably search, tracking ballistic missiles, surveillance, etc. | development |
| 10-stage, head-on, flat-face type | | detection of red & near-IR radiation | production |
| Ge PN alloy junction, photojunction | 50° C | high near-IR sensitivity | production |
| 6032: electrostatic focus; 6914, 6929: self-focusing monovoltage types | | near-IR viewing | production |
| Au-activated Ge; extrinsic photoconductivity | —196° C (liquid $N_2$) | hot-target perception; missile guidance | available |
| Hg-activated Ge; extrinsic photoconductivity | —253° C (liquid He) | perception of relatively low-temperature objects (people, terrain, etc.); missile guidance-recon | R&D |
| Cd-activated Ge; extrinsic photoconductivity | —253° C | | available |
| Cu-activated Ge; extrinsic photoconductivity | —253° C | | available |
| InSb; intrinsic photoconductivity | —196° C | hot-target perception; missile guidance | R&D |
| Mn-Ni, Co oxide, bolometer | ambient | target detection, recon, surveillance, spacecraft stabilization | production & special-purpose devices |
| InSb, single crystal, photovoltaic, area | 77° K | missile guidance, search-track systems, spectrometry, IR mappers | production; high D*, proven performance, high stability |
| InSb, single crystal, photoconductive, area | 193° K | missile guidance, surveillance | developmental; suitable for Peltier cooling; D* (500, 1000, 1)=2x10⁹ |
| Cu:Ge, single crystal, photoconductive, area | 4.2° to 15-20° K | surveillance, spectrometry | production; high D*, fast response, high stability |
| InAs, single crystal, photovoltaic, area | 250° K | missile guidance, surveillance, search-track systems | developmental; suitable for Peltier cooling; high stability & sensitivity |
| Si, single crystal, photovoltaic, area | 300° K | surveillance, missile guidance | pilot production; high D*, small size, high uniformity & stability |
| S-1 photocathode (cesium silver oxides in thin films) | —55° to +70° C | night vision by direct view | major production |
| thermicon | ambient (?) | | classified |
| thermally sensitive retina on which a scene is imaged; readout similar to TV camera pickup tube | uncooled | high-data-rate imaging system | advanced developmental models available |

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SURVEY

# PNPN devices

by **James R. McDermott,** Electronics Consultant

THE MOST WIDELY applied PNPN semiconductor device is the semi-bistable silicon-controlled rectifier (SCR), which is a solid-state equivalent of the thyratron, or latching relay. Once triggered on, it cannot be turned off by a control signal, but only by removal or reversal of the main supply voltage. There are also bistable silicon PNPN devices, which can be triggered both on and off, and the most recent PNPN development is a photosensitive device that can be turned on or off by the application or removal of light or can operate in a semi-bistable mode like the SCR, triggered by either light or a control signal.

The SCR is used chiefly for switching or control. It can handle 1-150 amp average and up to 500 V peak inverse. The bistable devices use currents on the order of 1-400 ma and are suitable for a wide range of computer circuits providing memory, timing, gating, counting, and other logic functions.

The static and operating characteristics of SCRs and bistable devices are similar and, except for the triggering-off feature of the smaller devices, the basic operation is the same for both types. All PNPN devices have three interacting PN junctions (*Fig. 1*). Two of these form a high-gain NPN silicon transistor. The third, together with the collector-base junction of the NPN, forms a PNP transistor, so that there is a solid-state circuit with internal feedback.

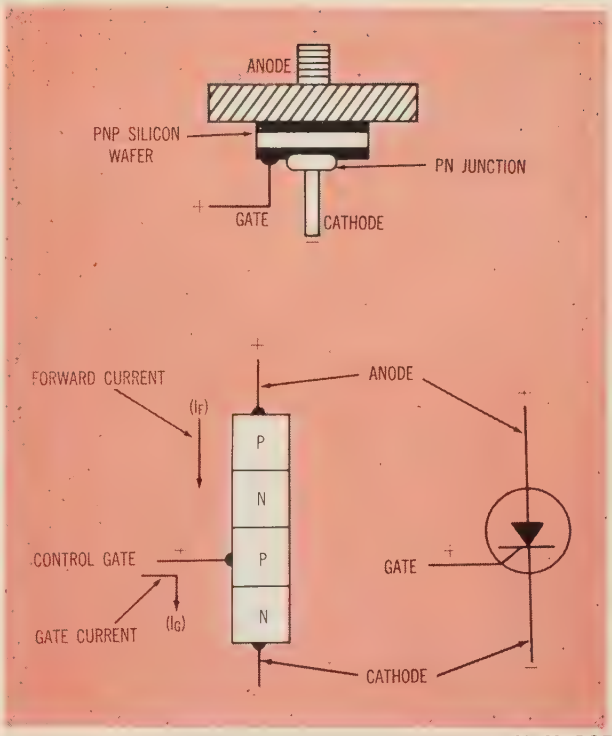
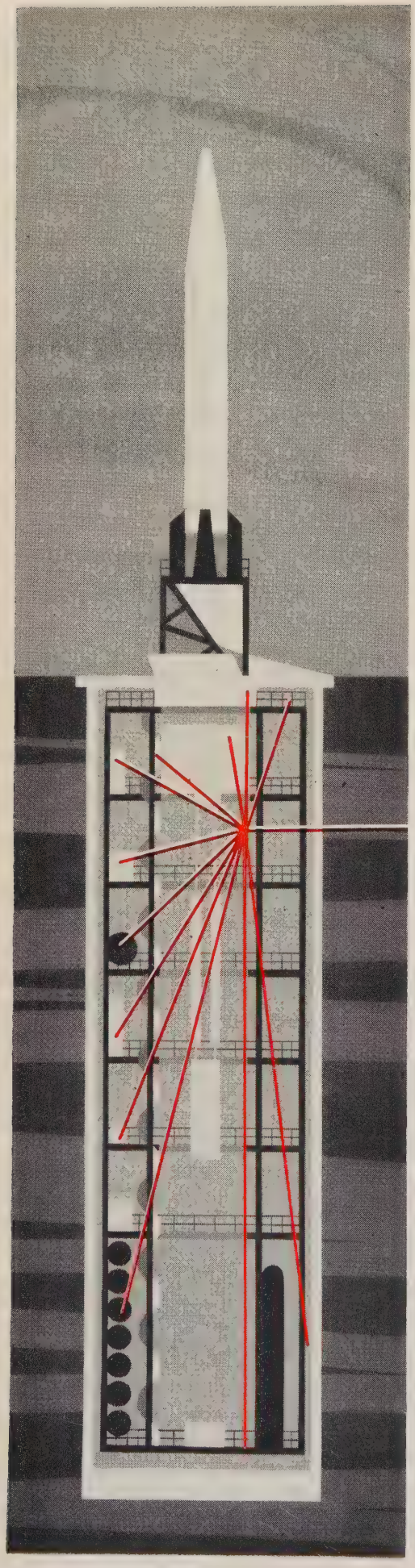



**FIGURE 1:** Construction of Q representative PNPN SCR (left), arrangement of PNPN layers in the silicon wafer and directions and polarities of operating currents and voltages (center), and schematic diagram of an SCR (right).

## IN BRIEF

*The basic advantage of all PNPN semi-conductor devices is that they reduce the size and complexity of circuitry. High-power PNPN silicon-controlled rectifiers, which are thyratron-like switches with a very low forward-voltage drop and turn-on and turn-off times substantially better than those of thyratrons and magnetic amplifiers, are used extensively in aerospace power supplies. A more recent development is a family of lower-power solid-state PNPN switches that can be triggered by powers as low as 12 uw and are superseding as well as complementing transistors in many circuits.*

*Also available are PNPN devices that can be triggered off as well as on. These units substantially reduce the number of parts required in memory, timing, counting, and computer logic networks. The very latest PNPN device can be triggered by light, by a control current, or by both.*



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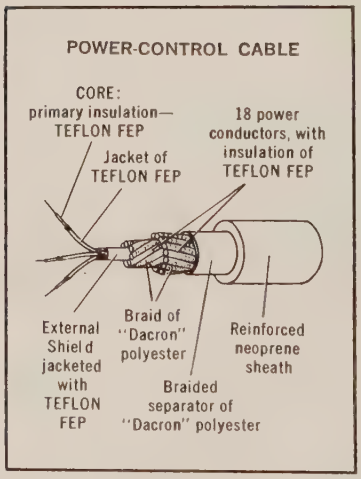
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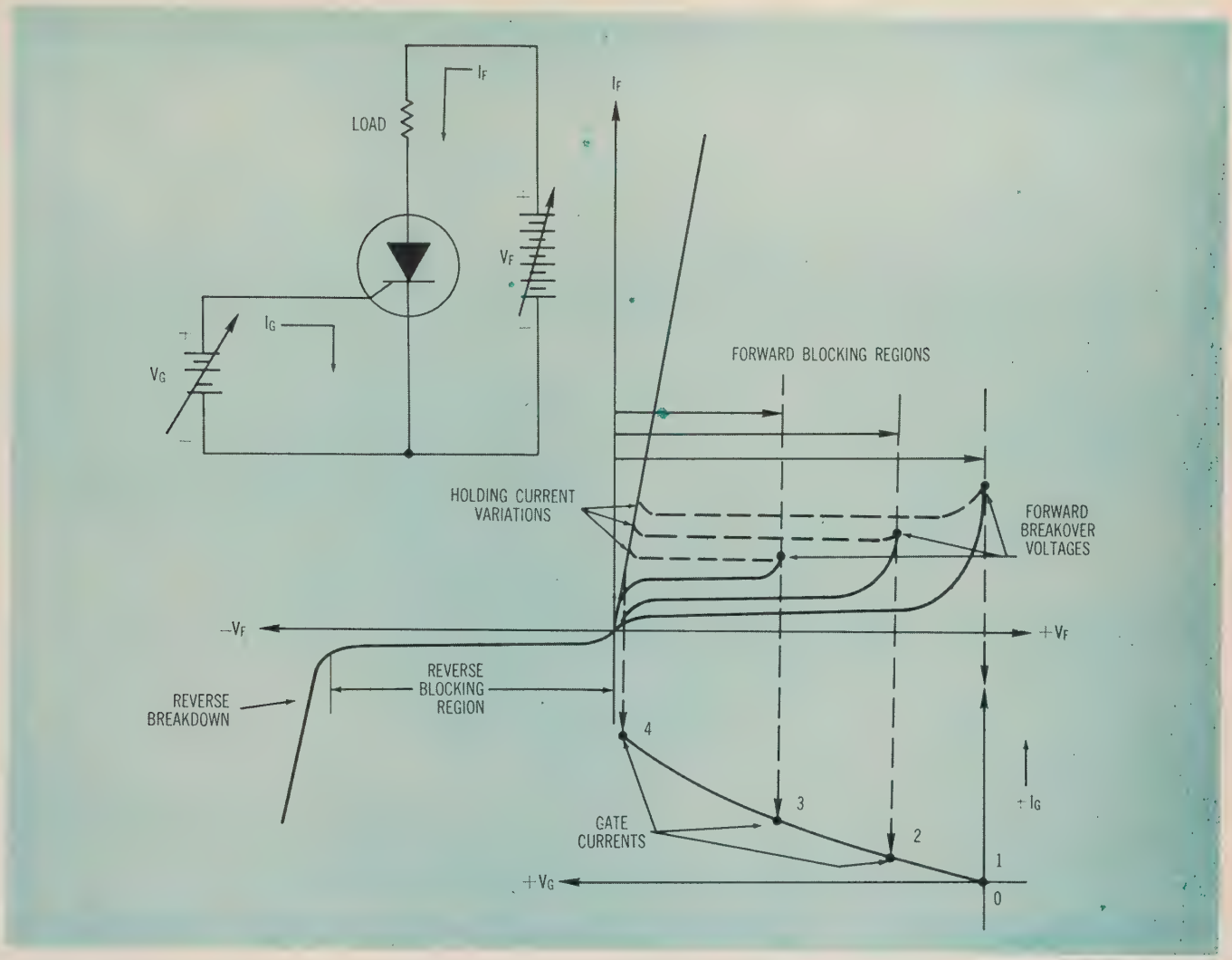



**FIGURE 2:** Operating characteristics of an SCR, showing the variation of forward breakover voltages with gate current. $I_F$ rises within microseconds to a limit set by the load.

The PNP wafer is attached to the anode connection, which is the mounting stud of the high-power SCRs. Low-power SCRs and the other PNPN devices may use a single lead as the anode or may be packaged in standard transistor cases. The cathode of the SCR is produced by diffusing a smaller area of N-type silicon into the open P-layer to form the third PN junction. The "gate," or control, lead is attached to the diffused P layer.

Positive voltage is applied to both anode and control gate for forward load current ($I_F$) and forward gate current ($I_G$). The SCR can be turned on, or made to conduct, by raising the voltage across it to a critical firing level or by applying the gate current. In practice, it is triggered by the gate current so as to obtain high power amplification.

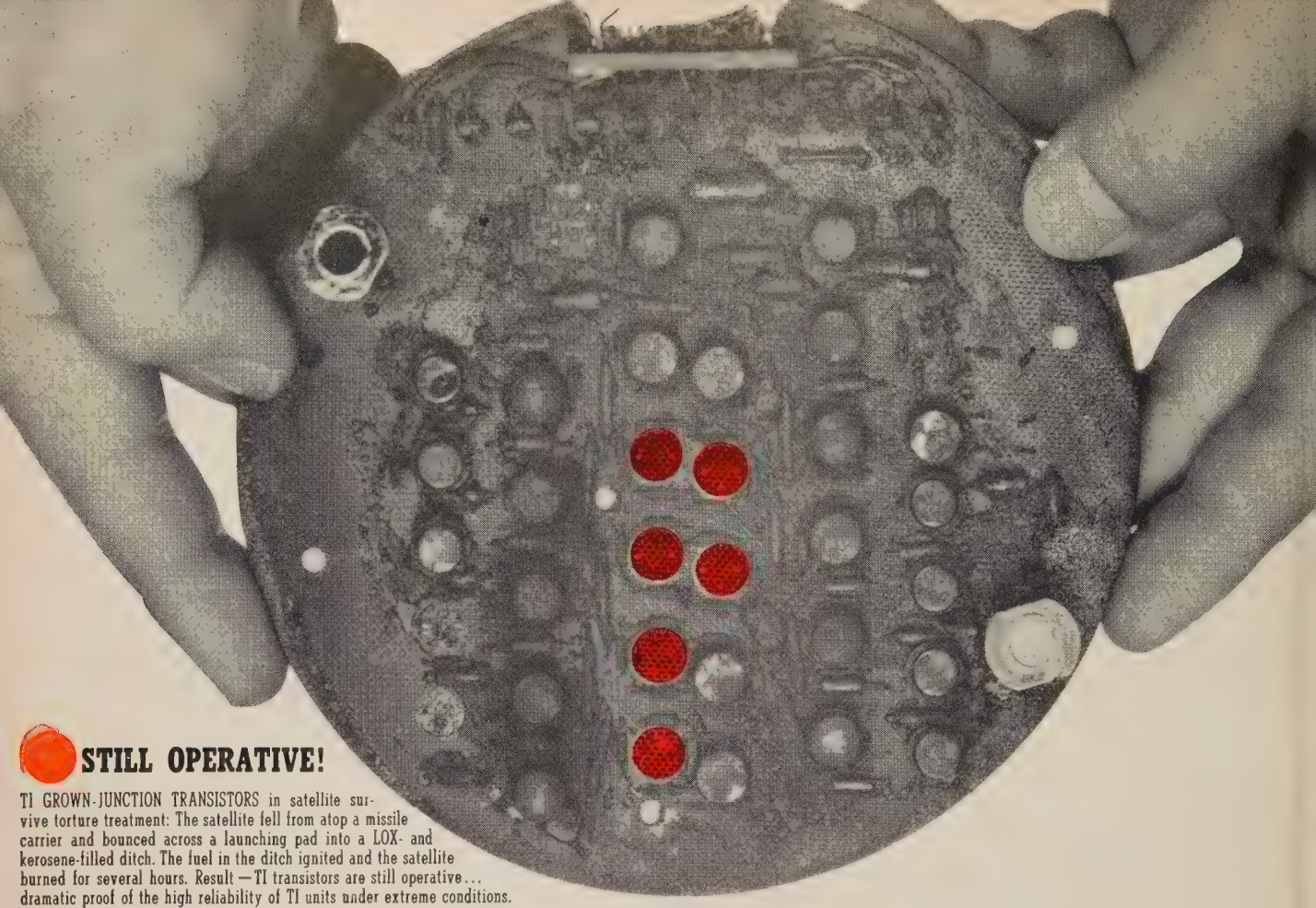
The operating characteristics of SCRs show that, at zero gate current, the forward voltage ($V_F$) across the SCR may be increased from zero to some higher positive value, with the forward current remaining very low until the voltage reaches the breakover point (*Fig. 2*). At this point, the voltage across the SCR snaps back to a low value and the forward current jumps swiftly to a maximum value determined by the load. The internal resistance is now a minimum, and the SCR is *on*.

When $I_F$ is reduced below the holding value by interrupting or reversing the supply voltage, the SCR is returned to the blocked state, and conduction ceases. During a voltage reversal, the two PN junctions act as two back-biased diodes in series. Forward conduction cannot be renewed until the forward blocking voltage is again raised to the breakover point.

This point is lowered if the gate current is increased (*Fig. 2*). At a low gate current (point 2) the device conducts at a lower forward voltage that at zero gate current (point 1). Increasing $I_G$ to point 3 further reduces the firing voltage. When the gate current exceeds a certain high value (point 4), the forward blocking region vanishes, and the SCR conducts like an ordinary diode rectifier.

The gate signal may be constant or may be a pulse. In either case the gate current must exceed the minimum required for reliable firing without exceeding the allowable dissipation limits, or the SCR's characteristics will be permanently degraded.

GE's C35 SCR, for example, has a maximum allowable peak positive voltage between gate and cathode of 10 V, and its peak negative voltage should not exceed five volts (*Fig. 3*). The maximum peak current is two



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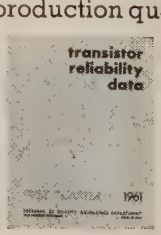


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| Max. reverse or forward leakage current (full-cycle average) | 5 ma |
| Max. forward voltage (full-cycle average) | 0.86 V |
| Typical holding current | 10 ma |
| Typical firing gate current at +1.5 V | 10 ma |
| Typical turn-on time | 1.0-4.5 usec |
| Typical turn-off time | 10-20 usec |
| Operating temperature range | —65 to +125 deg C |
| Max. thermal resistance (junction to stud) | 2 deg C/W |

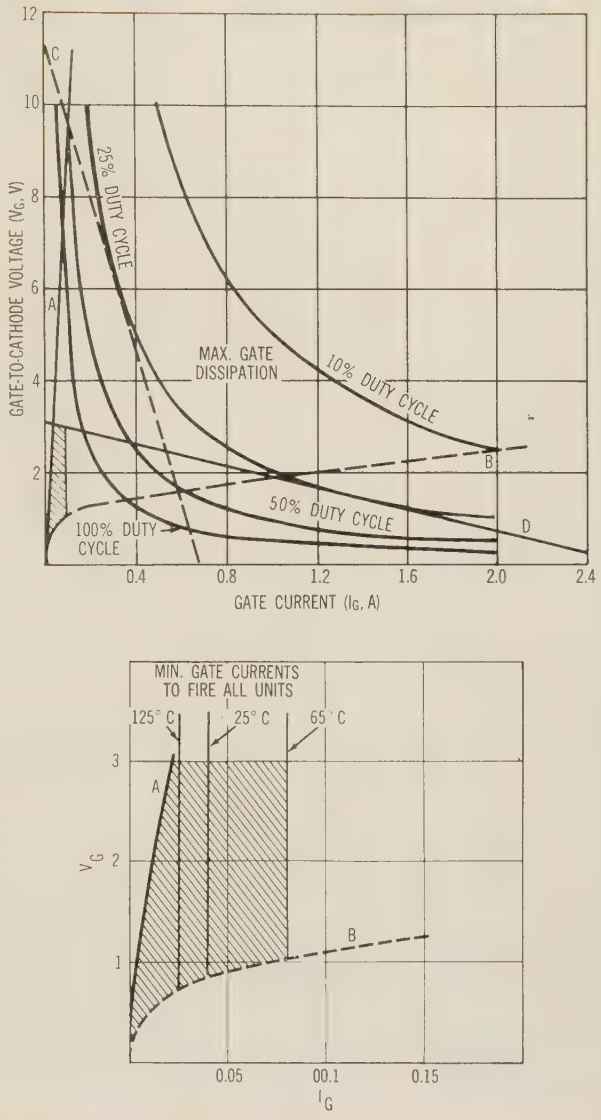


**FIGURE 3:** Characteristics of GE C35 SCR and gate signal limitations for positive firing within temperature limits. The shaded area representing the locus of all possible firing points between —65 and 125 deg C is shown expanded at bottom. Lines A and B show the limits of the voltage-current characteristics between gate and cathode; lines C and D, the load limits for a gate signal duration of 25 per cent. Peak allowable $V_G$ is 10 V; peak allowable $I_G$, two amperes; minimum gate voltage to fire all units, three volts; and maximum $V_G$ that will not fire any units, 0.75 V at —65 deg C and 0.25 V at 125 deg C.

amperes, while the peak gate power dissipation should not exceed five watts and the average power should not exceed 0.5 W. For reliable firing within these power limitations, over the range of —65 to 125 deg C, both gate signal voltage and current should fall outside the shaded area in *Figure 3*, and the load lines should remain above and to the right of this area.

As protection against excess inverse gate voltage, a diode clamp is connected from cathode to gate (*Fig. 4*). To forestall thermal runaway due to a positive gate voltage while inverse voltage is being applied to the the anode, a diode and a series resistor are connected between gate and anode.

Random triggering in the absence of a trigger signal may occur in gate circuits that have a standby leakage current (as in saturable reactors and unijunction transistors). To prevent it, a bleeder resistor is connected between gate and cathode whose resistance is low enough to keep the voltage across it to below 0.25 V.

The turn-on and turn-off speeds of SCRs are substantially better than those of magnetic amplifiers and thyratrons. With a steep gating wavefront on the order of a few millimicroseconds, the current in a C35, for example, rises to full-load values within 2-6 usec. The current does not go up instantly—after the beginning of the gate pulse, a delay ($t_d$) persists for a few tenths of a microsecond (*Fig. 5*). It is followed by a rise time ($t_r$) that depends primarily on the load characteristics.

For purely resistive circuits, $t_r$ decreases with increasing forward voltage and decreasing maximum load current. Delay and rise times are temperature-sensitive and increase by 20 or 30 per cent from 25 to 100 deg C.

Once an SCR conducts, the gate loses control. To stop conduction, the positive anode voltage must be removed or reversed long enough so that the device can recover and return to the blocked state. This recovery depends

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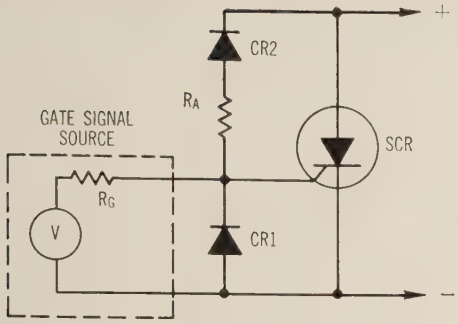


**FIGURE 4:** Clamp circuit for protecting SCR gates against excessive and damaging currents.

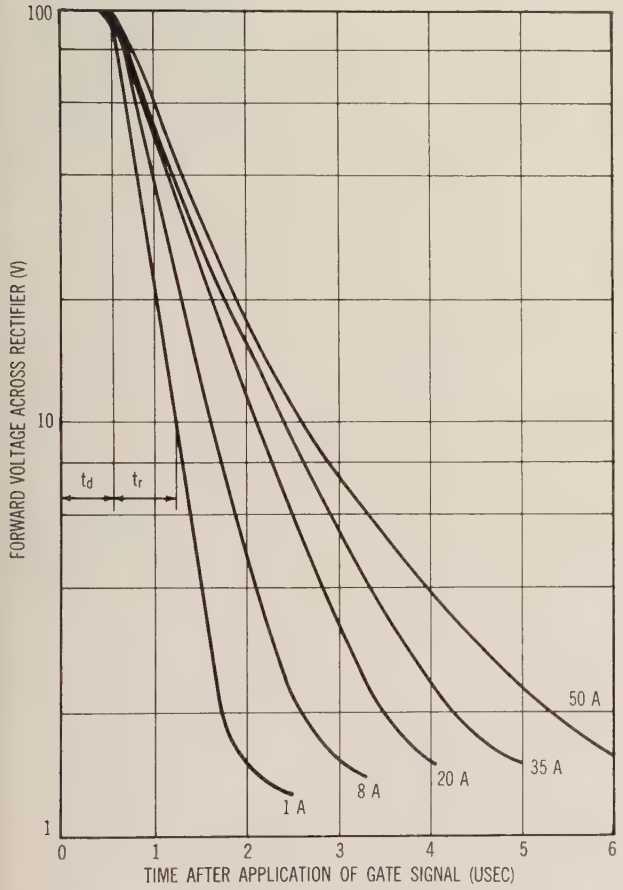


**FIGURE 5:** Typical turn-on times for C35 SCRs at various load currents and 100 V blocking voltage, 100 ma gate current pulse, 0.02 usec gate signal rise time, and 30 deg C junction temperature.

on several factors, which makes the problem of turn-off somewhat more complex than that of turn-on. The recovery time increases with junction temperature, load current, rate of decay of the load current, reapplied forward voltage, and rate of rise of the forward voltage. It decreases with increasing inverse voltage, increasing rate of rise of the inverse voltage, and decreasing circuit impedance during turn-off. The C35, for example, may require a minimum of 10 usec to block forward volts at a 25-deg C junction temperature (*Fig. 6*).

So long as the reapplied voltage does not rise faster than at the rate allowable for a given temperature, an SCR will block and stop conducting. *Figure 6* shows that, in the case of a typical parallel inverter circuit, the voltage rises from a negative value after commutation.

When SCRs are supplied by AC, the reversal of each cycle of the supply voltage turns the rectifier off and lets the gate regain control. With DC supplies, the problem is more complicated, and a variety of solutions has been worked out for it.* In such DC circuits as circuit breakers and high-speed latching relays, a manual or automatic switch in series with the rectifier can be opened momentarily. For other types of circuits, capacitors can provide a reverse cut-off voltage (*Fig. 7*). They may be connected either in series (in pulse circuits) or in shunt.

For the shunt circuit, the minimum value of C is given by:

$$C \geqq 1.4 t_o I / V \quad uf,$$

where $t_o$ is the turn-off (in microseconds); $I$, the steady-state current (in amperes); and $V$, the main supply voltage. To keep the reverse recovery current at a safe level, an LR network can be connected in series with C.

Typical applications of SCRs are AC or DC solid-state switches, solid-state latching relays, phase-controlled AC supplies and rectifiers, regulated power supplies, transient-voltage limiters, servo drives, power flip-flops, current-limiting circuit breakers, DC-AC inverters, DC-AC converters, and power pulse generators. The control quantity can be heat, voltage, current, pressure, speed, frequency, phase, or any other function that can be

* "Controlled Rectifier Manual," GE.

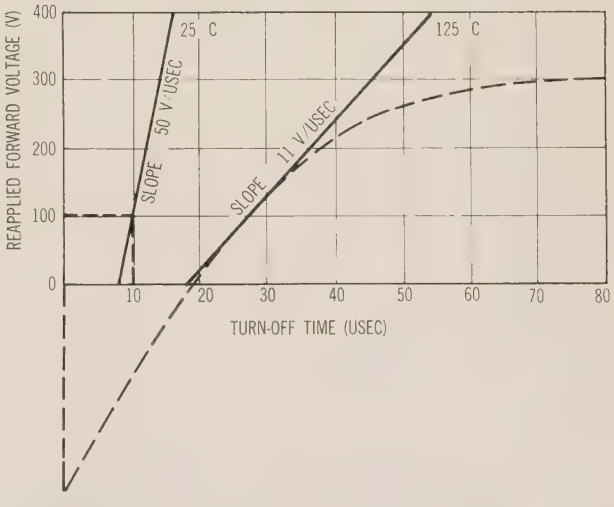


**FIGURE 6:** Junction temperature vs turn-off time for C35 SCR at 10 A forward current, 300 V forward voltage, 10 V peak inverse voltage, and three ohms reverse-recovery circuit resistance. The dashed lines below the zero axis show reverse voltages, which must rise more slowly than the slopes of the junction-temperature lines to insure effective turn-off. At low frequencies, the reverse-recovery time normally can be ignored; at 10-15 kc or more, it must be evaluated. In the typical parallel inverter circuit, the voltage rises from a negative value after commutation, as shown by the curve of the maximum rate at which the voltage may rise at a junction temperature of 125 deg C.

## NEW TAPES TAME DESTRUCTIVE HEAD-HEAT COMPLEX

SCOTCH® BRAND *Heavy Duty Instrumentation Tapes take new speed and friction tensions in stride!*

Today's trend to speed-up in the recording of instrumentation data—with tape speeds up to 120 inches per second—can mean "*Slow Down, Trouble Ahead!*" for tapes that can't cope. On the other hand, "SCOTCH" BRAND Heavy Duty Tapes love to live dangerously—are made for challenging environments where tape speeds are fast and getting faster, where instantaneous temperatures caused by friction between tape and head shoot up. Two new "SCOTCH" Tapes—Heavy Duty Tapes 498 and 499—are especially designed for applications where ordinary tapes soon wear out.

*They live 15 lives.* Actual field tests show that "SCOTCH" BRAND Heavy Duty Tapes last 15 times as long as standard tapes . . . stoutly resist high temperatures, both externally and internally generated. In instrumentation uses, where tensions caused by friction and heat make tape wear an important factor, these Heavy Duty Tapes preserve the integrity of the coating, minimize rub-off and particle redistribution that separate tape from head . . . and *you* from a signal.

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*High conductivity* is another feature of "SCOTCH" Heavy Duty Tapes . . . nearly 1000 times that of conventional tapes! Static charges drain off without building up . . . you get a smooth, clean tape pass every time, with excellent resolution. This efficient static drain-off makes stray contaminants less likely to be attracted to the tape.

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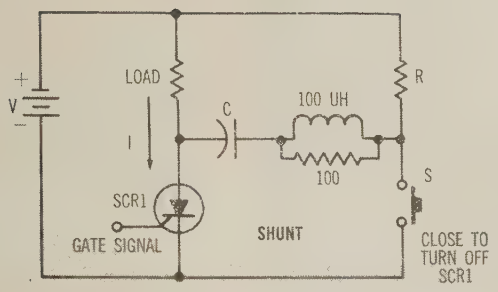


**FIGURE 7:** Capacitor turn-off circuits. In shunt turn-off, the load voltage charges C through R when SCR1 conducts, so that the right-hand side of C becomes positive with respect to the anode. To stop conduction, S is momentarily closed, and the positive voltage across C is applied to the cathode. This reverse-biases the rectifier and reduces the load current long enough for the device to regain the forward-blocked state. The values shown are for a C35 operating at a maximum allowable junction temperature of 125 deg C, at which R must not exceed 20 times the supply voltage. (It can be higher at lower temperatures.) In series turn-off, the load current is produced by the discharge of C into the load. When SCR1 is triggered with C discharged, a pulse of charging current flows through L. Because of the inductance of L, C charges to nearly twice the supply voltage's level. When the forward current ceases to flow, the charge on C reverse-biases and turns off SCR1. The charge then drains off through the load. This circuit is often used in inverters and similar devices. The value of C is chosen so that the reverse bias exceeds the minimum cut-off level for a period longer than the SCR cut-off time.

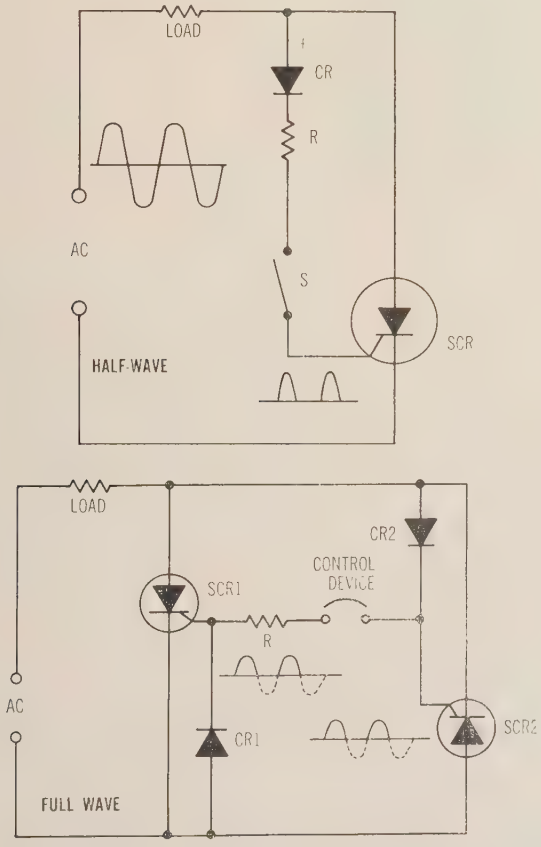


**FIGURE 8:** AC control of gating circuits. In half-wave switching circuits, the gate current flows through diode CR and current-limiting resistor R when the SCR anode is positive. When S is closed, the SCR is gated on the positive half of each cycle. CR prevents the application of excessive inverse voltage between cathode and gate during the negative half of a cycle. If S is opened, the load current will be interrupted within one-half-cycle. The operation of full-wave switches is the same, with SCR1 and SCR2 conducting on opposite halves of the cycle.

converted to trigger the magnetic core, transistor, electron tube, or other device providing the actual gate signal. *Figure 8* shows solid-state half- and full-wave switches that represent basic AC applications. For simple *on-off* control, a constant DC gate signal is adequate provided the allowable gate dissipation is not exceeded. The gating problem can be simplified by connecting the gate to the anode side of the supply. The full-wave switch is particularly well suited for the fast switching of AC power on loads with a high duty cycle.

The output of these static switches can be varied by

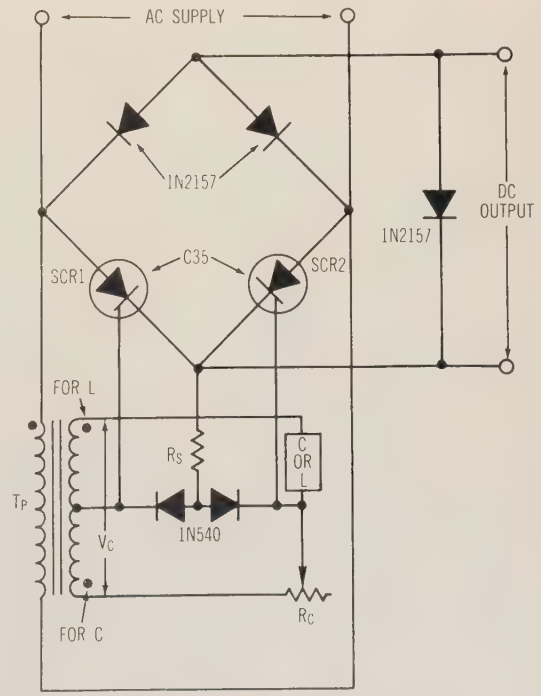


**FIGURE 9:** Phase-controlled full-wave rectifier. Its output is varied by phase-control $R_C$.

# 61 POWER CONTACTS IN A 1⅛" SHELL



## NEW MICRODOT MICROMINIATURE MULTI-PIN CONNECTORS

**These rugged, reliable "43" Series Microdot Microminiature Multi-pins are only ¼ the size, ⅓ the weight of previously available miniature multi-contact connectors. Yet performance equals or exceeds MIL-C-26482 and applicable paragraphs of MIL-C-26500. Ready now for advanced applications, these connectors pack up to 61 power contacts—or 19 coaxial contacts—or a combination of both—into a shell the diameter of a quarter.**

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**Microdot Multi-pin Connector Kit**

| SIZE DESIGNATION | PLUG O.D. | NO. OF COAXIAL CONTACTS | NO. OF POWER CONTACTS |
|---|---|---|---|
| A | ¾" | up to 7 | up to 19 |
| B | 1⅛" | up to 12 | up to 37 |
| C | 1⅛" | up to 19 | up to 61 |

**MICRODOT INC.**

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## Microminiature Coaxial Connectors

Microdot's microminiature connecto —including the world's smallest 5 ohm coax connectors—are available over one million combinations. Plu are available in straight or angle scre types and slide-on versions. Rece tacles include printed circuit and bul head feed-thru types. Only highe quality materials are used. Conducto are of silver-plated copperweld or ca mium bronze, center contacts are gold-plated coin silver. Housings a silver-plated brass to assure minimu electrolysis with aluminum panel "Teflon," "Kel-F," polyethylene, an neoprene are used as dielectrics, jac ets, bend relief caps, and pin protector

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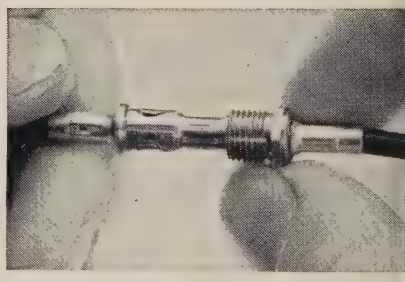
## Crimp-type Connector



These solderless, coaxial connecto are available in a variety of mountin configurations, including snap-lockin versions. Male and female connecto may be mounted interchangeabl Mated length is 1¹³⁄₁₆". Working vol ages: 1,000 V. maximum, at sea leve 500 V. maximum, at 60,000 fee VSWR; less than 1.2 up to 2,000 m Life; 5,000 matings, minimum, witho electrical deterioration. Tensile strengt of the crimps exceed the breakin strength of the cable. Hard gold plate Beryllium copper and TFE plastic a extensively used to assure optimu reliability.

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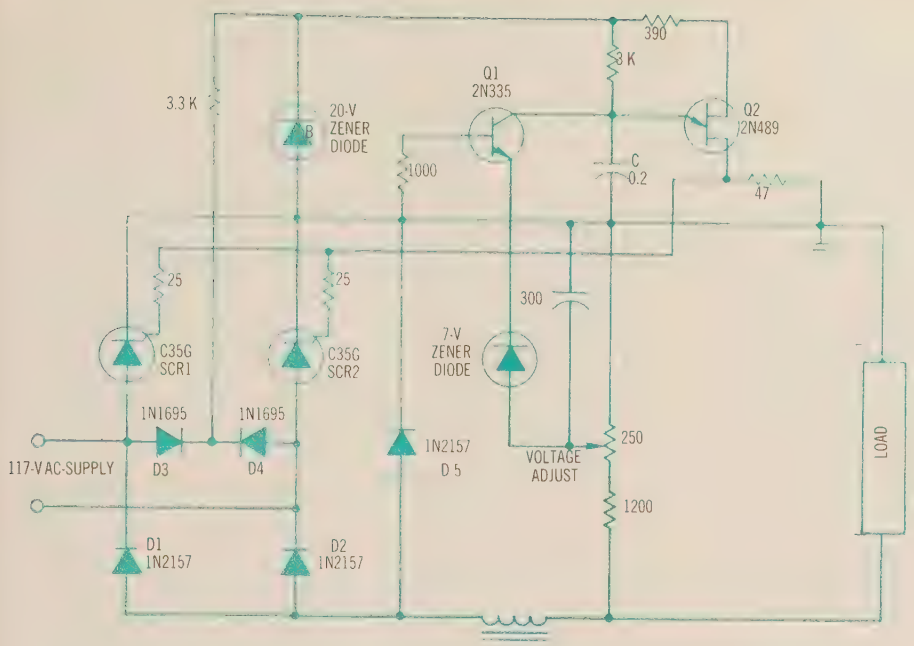



**IN PHASE-CONTROLLED** regulated power supplies, SCRs maintain a constant output voltage by controlling the phase shift through a unijunction transistor. In this case, the output voltage is held within ±0.5 V for a line-voltage change of ±20 per cent and load-current variations from zero to full load. The phase of the SCR gate voltages is shifted by phase-shifted pulses from unijunction transistor Q2. The shunting action of transistor Q1 on capacitor C provides feedback control of the firing angle. A rising input voltage or a reduced load tends to raise the voltage output, but it also holds down the phase angle and restores the normal output voltage.

shifting the phase of the gate signal with respect to that of the anode voltage, as in the full-wave phase-controlled rectifier of *Figure 9*. If such a circuit uses C35s and is designed for maximum phase shift and positive triggering down to —65 deg C without exceeding the gate input limitations, the series resistance is:

$$R_S = (V_C - 20)/0.2 \text{ ohms}.$$

Depending on whether capacitance is used in the shifter or inductance, the phase-shift control resistance is, respectively:

$$R_C = 10/(2\pi fC), \quad R_C = 10/(2\pi fL),$$

where $f$ is the line frequency and $C$ is in farads and $L$ in henries. The peak voltage ($V_C$) of the secondary of the phase-control transformer ($T_P$) should exceed 25 V and, depending whether the phase element is capacitive or inductive, agrees with:

$$0.5V_C - 9 = 1/(2\pi fC), \quad 0.5V_C = 1/(2\pi fL).$$

Because the phase-shift network is frequency-dependent, the inductive or capacitive elements are easier to select at higher frequencies.

## SCRs in AC-DC power conversion

SCRs play an important role in the conversion of DC power to AC with series or parallel inverters. Series inverters have one or more capacitors that are alternately charged and discharged into the load. Because the energy stored in a capacitor depends only on capacity and supply voltage, the energy delivered to the load (per cycle) is independent of the load.

In its basic form, the series inverter has two major drawbacks (*Fig. 10*): All energy supplied to the load must flow through L and C2 (which therefore must be of large size) and the high load requirement limits the range of circuit applications. More advantageous is an improved circuit in which the voltage to which C charges increases with the load current, making it possible to communicate heavy loads by charging the capacitor to correspondingly higher voltages. This design usually also saves space, because the low-capacity, high-voltage capacitors are smaller than high-capacity, low-voltage units.

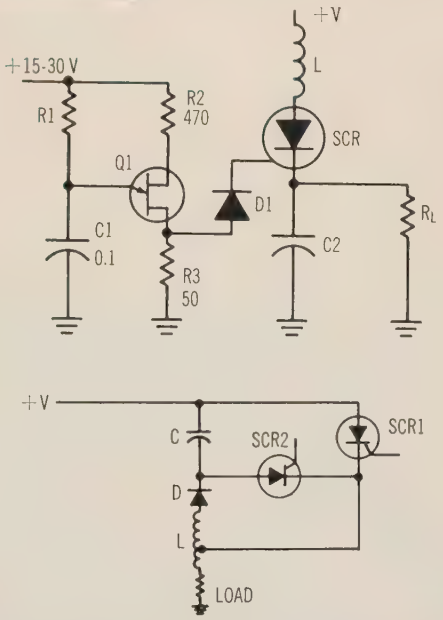
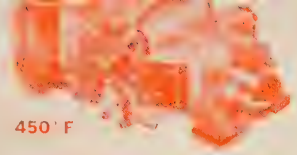



**FIGURE 10:** In basic series inverters (top), unijunction transistor Q1 is a relaxation oscillator that produces a short pulse across R3 whenever C1 is charged to the peak point, at a rate of about $1/(R1 \times C1)$. Each pulse fires the SCR, charging C2 through L. With a sufficiently large load resistance, circuit Q is high enough to produce an oscillatory discharge. At the end of the first half-cycle, the current reverses, the SCR blocks, and C2 is charged to a voltage higher than the supply. At that point, the capacitor discharges through the load (usually a step-up transformer). In improved series inverters (bottom), turning on SCR1 charges C to twice the supply voltage or more via the resonant LC charging circuit. The load current flows until SCR2 fires, cutting off SCR1. The charge on C then dissipates into the load. The tapped choke makes the capacitor inrush current flow in the direction opposite to that of the load current, providing a flux resetting action. The load voltage is a square wave whose duration and frequency depend on the repetition rate of the gate pulses rather than on the constants of the LC network.



450° F

Mach 3 starter motor/pump

500° F

Hot gas servo valve

600° F

Titanium rudder actuator

600° F

Hi-temp servo valve

400° F

Dual pump for X-15

# CAPABILITY is spelled

## M-a-c-h 3 s-y-s-t-e-m-s

Flight speeds of Mach 3 and higher introduce new problems in auxiliary power system design a operation. A well defined program* in existence for more than six years at Vickers has been devot to high temperatures—in the 350° to 1400° F range—and their effects on materials, fluids a tolerances.

**Exotic Fluids**—Systems have been designed and tested for a broad range of hard-to-hand fluids including: deodorized kerosene at 350° F . . . synthetic base fluids (MLO 8200) at 450° F . super refined mineral oil (MLO 7243) at 700° F . . . mixed isomers of bis (phenoxyphenyl) ether 700° F . . . liquid metal (NaK 77) at temperatures to 1400° F.

**Hi-temp Components**—Specialized high temperature applications require parallel activity servo systems and related components (see examples at left). A typical development progra includes servo valves for the −65° to 500° F range with extremely low thermal drift.

**Compatible Materials**—Related studies evaluate manufacturing and application problems materials including tungsten and titanium carbides, titanium and high alloy stainless steels. All ha optimum application in providing extra strength needed at minimum additional weight on actuato valves, pumps and subsystems packages.

Specific facts about Vickers accumulated experience, facilities and "hardware" delivered a available. Ask for Bulletin A-6004.

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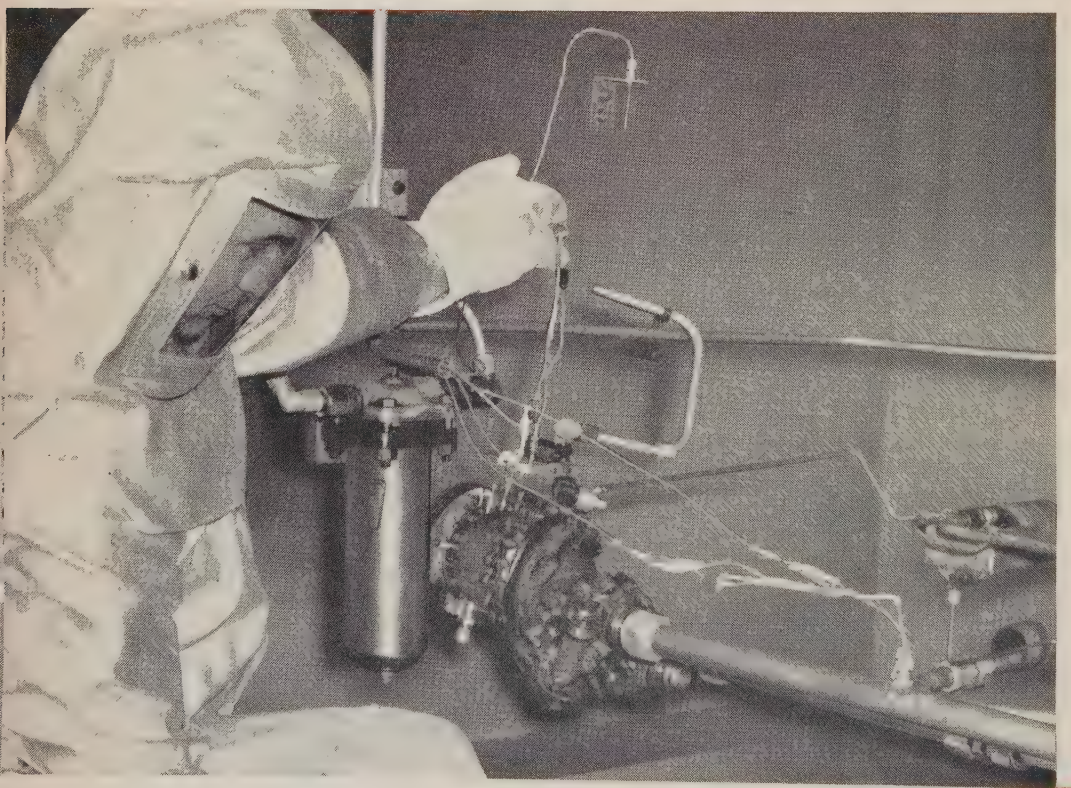
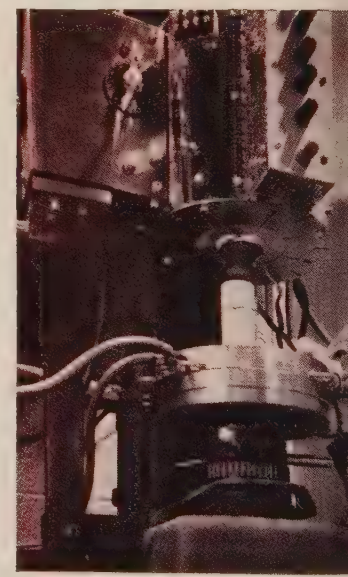


At completion of high temperature test, technician removes prototype pump that is heart of system being developed for Mach 3 flight. Systems are often hermetically sealed and pressurized with inert gas, necessitating special test facilities to simulate operating conditions.



Hot hardness tester is used to pred behavior of special alloys dur extended operations at elevat temperatures.

Maximum safety building located at some distance from main research facilities has test cells used extensively in high temperature tests.

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Parallel inverters are often used to convert DC to AC and generally make better use of SCRs than do series types and provide better regulation. However, they lack inherent protection against short circuits in the load and must operate at lower frequencies than the series types.

## Light load conditions are tricky

In the standard parallel inverter, the capacitor (C) is charged to twice the supply voltage when SCR1 is conducting so that, when SCR2 conducts, the anode of SCR1 drops below ground and cuts off SCR1 (*Fig. 11*). The value of the choke (L) is high enough to make the supply look like a constant-current source. C is large enough to compensate for the reactive KVA of the load and to maintain bias on the SCRs long enough so that they become blocked during the turn-off period.

Under light load conditions, the voltages on the SCRs of this type of inverter may become too high and commutation may fail, so that both SCRs conduct at the same time. W. McMurry and B. D. Bedford, of GE, have developed an improved inverter that avoids these dangers (*Fig. 11*). In their circuit, C and L are much smaller and are chosen to produce an oscillatory pulse across L when the second SCR is triggered. The diodes compensate for leading or lagging power factors. With reactive loads, the gate signals are applied for at least one-quarter of the cycle to keep transient commutation currents from turning off an SCR before the end of a half-cycle.

## AC inverter output is rectified

Circuits for the conversion of DC at low voltage to DC at high voltage as a rule use the parallel-type DC-AC inverter. In any case, the AC inverter output is rectified and filtered to provide the specified degree of ripple-free DC.

SCRs are being produced in several current ratings from approximately one to 100 amp. For each of these ratings, there is a number of SCRs differing in the allowable repetitive peak reverse voltage. GE's C50, for in-

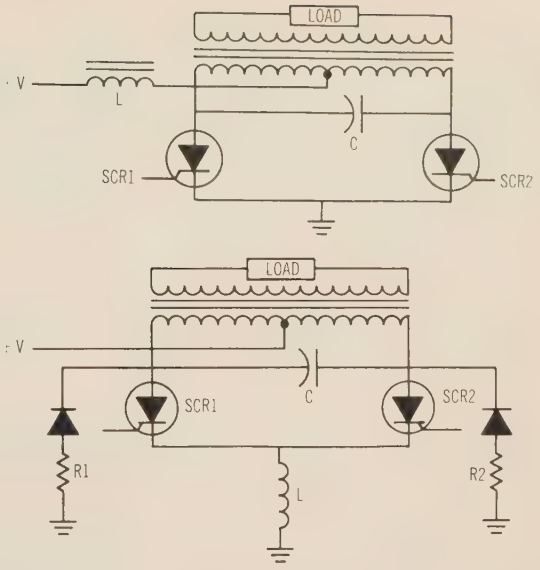



**FIGURE 11:** Standard parallel inverter circuit (top) used with thyratrons, ignitrons, and SCRs, and improved version (bottom) developed specifically for SCRs.

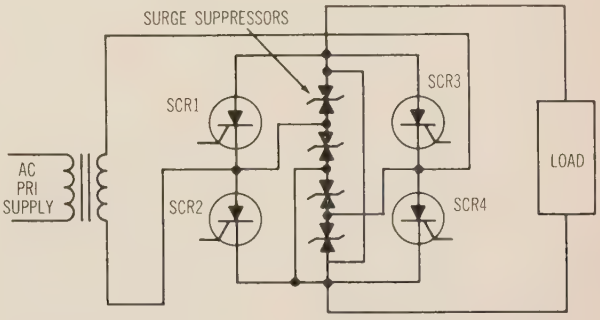
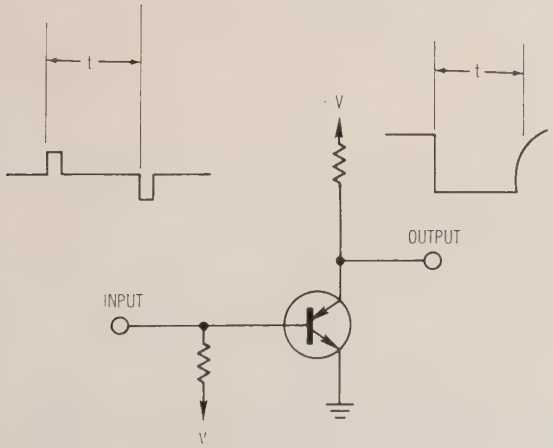
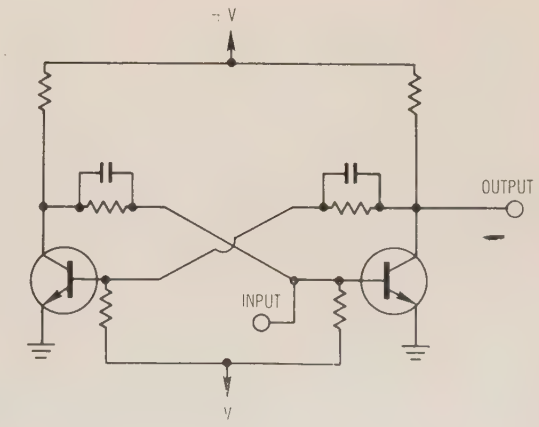



**FIGURE 12:** Bridge rectifier with Voltrap surge suppressors.

**FIGURE 13:** Bistable PNPN Trigistor flip-flop (left) and conventional transistor counterpart (right). The width of the Trigistor's output pulse is the time between the leading edges of the positive on-pulse and the negative off-pulse. If additional components are used, the Trigistor circuit can be made to operate with a string of positive-going pulses instead of with positive and negative trigger pulses.



# NEW

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## *features:*

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**PNPN SCR vs Silicon Power Transistor**

| SCR | Transistor |
|---|---|
| Heavy base region | Thin base region |
| High inverse voltage | Low inverse voltage |
| Turned on with trigger pulse; constant input not required for full conduction | Constant input required for constant output |
| Input-output power gain high (e.g., 50-ma input controls 16-A output) | Input-output power gain low (e.g., 0.5-amp base current produces 5-A collector current) |
| High load-current capabilities | Low load-current capabilities |
| Removal of input (gate) signal does not stop output current | Removal of input signal stops output current flow |

stance, is rated at a maximum average current of 110 amp and has nine sub-types with peak-reverse-voltage ratings from 25 to 500 V.

The cost of SCRs increases with the reverse voltage rating, and it's good design practice to specify the minimum reverse voltage that will do the job. Peak-reverse-voltage ratings can be reduced sharply by surge suppressors like the Westinghouse Voltrap or the G E Thyrector. These units are solid-state devices that have Zener characteristics over the range of 30-480 V RMS (in 30 steps). Breakdown action can be obtained in either one of the directions of current flow or in both.

## Voltages are kept to safe levels

Voltraps provide a shunt path for surge currents, clamp excessive voltages to safe levels, and (depending on type) can carry discharge currents of 2-80 amp. They make it possible to use SCRs with peak-reverse-voltage ratings only 10 per cent above the suppressor's clamping-voltage rating. In a typical bridge rectifier, they let you substitute an SCR rated at 350 V peak reverse voltage for one rated at 500 V (*Fig. 12*).

SCRs have triggering currents on the order of milliamperes and output currents on the order of amperes. For applications requiring very low gating currents, silicon-controlled switches are available. These have the same operating characteristics as do SCRs, but the gate current is on the order of microamperes and the controlled current on the order of milliamperes.

## Truly bistable PNPN is smaller

The truly bistable PNPN device—known variously as Trigistor (Solid State Products), Transswitch (Transitron), and Dynaquad (Tung-Sol)—is a good deal smaller than the typical SCR and can handle much less power. The turn-on and turn-off times of the bistable unit are shorter, providing triggering rates of 200 kc and higher. The turn-on characteristics of the smaller unit are the same as those of the SCR (*Fig. 2*), except for the magnitudes of current and voltage. The important difference is that the bistable device can be triggered off, too, by applying a negative gate pulse (or a positive one, depending on the circuit connections).

These bistable switching characteristics can be used to simplify computer logic circuits, as is shown by the Trigistor flip-flop of *Figure 13*.

Two or more basic circuits of this kind—including shift registors, binary counters, and ring counters using only half or one-third as many components as their conventional transistor counterparts—can be combined with coupling and logic networks to form simplified memory, counting, timing, and other standard computer circuits.

## Light triggers new photo switch

The most recent development in the PNPN field is Solid State Products' Photran, a photo-switch that is triggered by light energy instead of, or in addition to, gate control current. Before light strikes the Photran, the device's impedance in the off-state is 10 megohms or more. When light above a minimum triggering level strikes the sensitive area, the internal impedance drops to less than 10 ohms, and the device is on.

Only a pulse of light is needed to trigger the Photran on, since the device, like the SCR, remains on until the DC anode voltage is removed or reversed. The light intensity required for triggering is a function of the gate current. The Photran can also be triggered directly by gate current just like an SCR. Because of the particular characteristics of the Photran, AC should be used to keep the circuitry simple (*Fig. 14*).

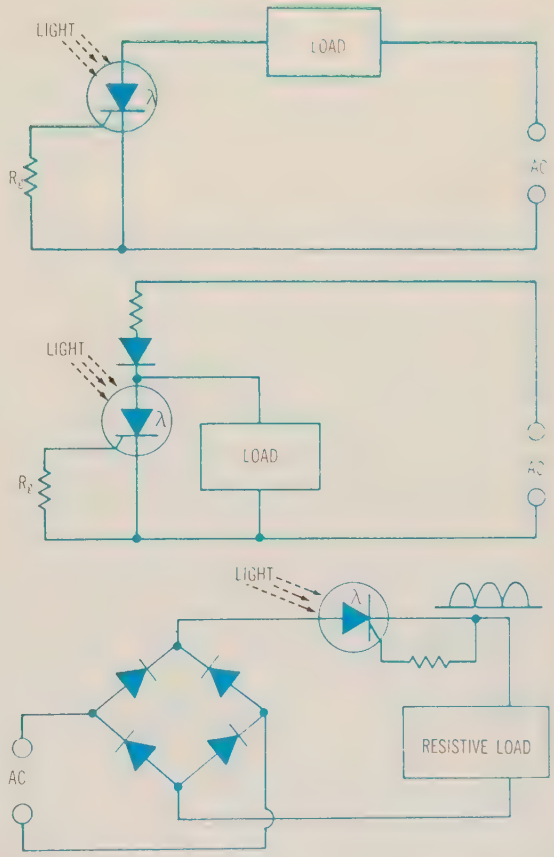
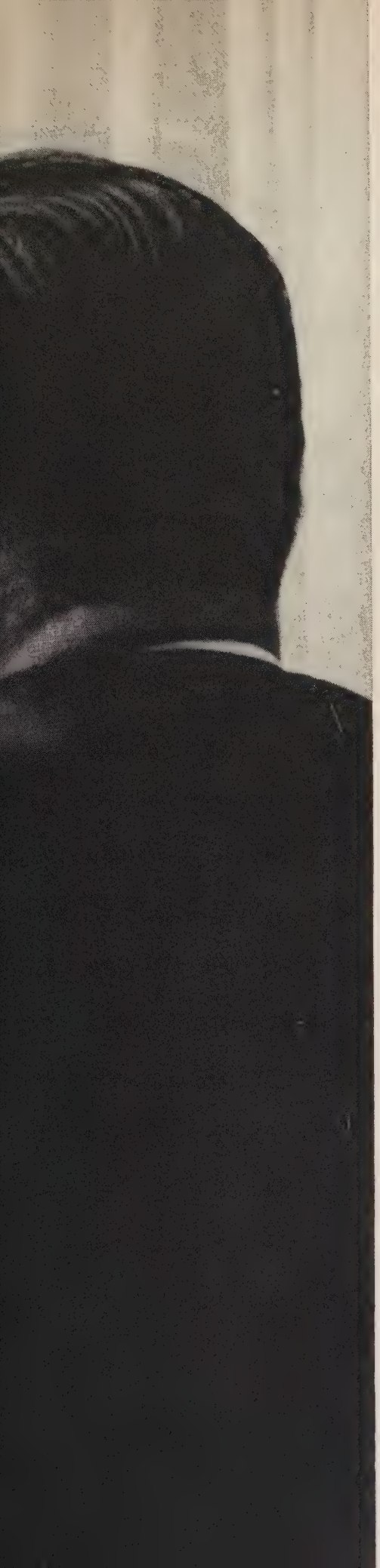



**FIGURE 14:** Basic Photran circuits include (top to bottom) a half-wave switch that conducts when light is applied, a half-wave switch that conducts when light is removed, and a gated bridge rectifier that delivers full-wave DC to the load when light is applied.



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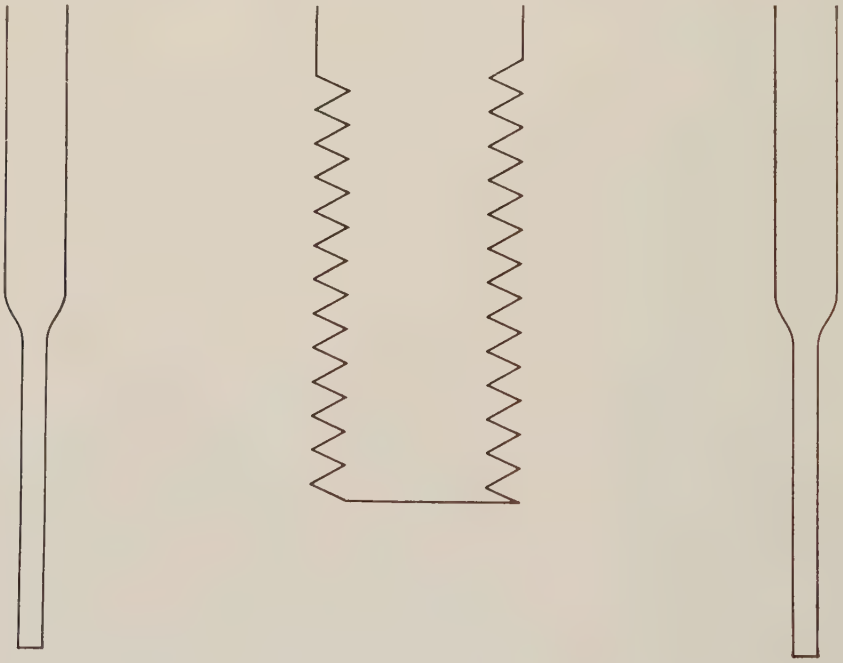

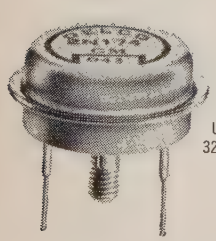

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# Space guidance

## highlighted at ARS meeting

PREDICTIONS about the weight, size, and cost of spaceborne digital computers, ideas for the design of nuclear gyros and optical Doppler systems, and a survey of the fundamental limits of inertial guidance sensors were among the technical highlights of the American Rocket Society's August 7-9 Guidance, Control & Navigation Conference at Stanford University.

What spaceborne computers will be like over the next decade was outlined by Adi J. Khambata and Roger A. Urban, of Remington Rand's Univac Division (*Fig. 1*). Their predictions were founded on two basic assumptions:

- The spaceborne computer of 1970 would have to have 10 times the processing capability of the typical tube-type, large-scale system of today with a million-bit memory.
- Transistors, tunnel diodes, and thin-film "microtronic" circuits are most likely to be used for logic and magnetic cores and thin films for memory elements.

Khambata and Urban foresee much of a future for parametrons made of inductive materials as elements of future computers, because of the inherently low speed and high current drain of these devices. On the other hand, they considered semiconductor-type parametrons promising.

The predictions about the physical characteristics of the logic portions of future spaceborne computers were based on three observations derived from an analysis of existing systems:

- The power requirements of the logic portion depend on the number of elements this portion contains. Doubling the number of elements approximately doubles the power consumption.
- The actual circuitry accounts for about one-

**Table I:**
**Expected Maximum Optical Doppler Variations**

| Effect | Variation (fps) |
|---|---|
| Second-order Zeeman effect | $10^{-24}$ |
| Quadratic Stark effect | $10^{-3}$ |
| Pressure shift | 4 |
| Sunspot effect | 37 |
| Variability of radius | 150* |

* Mean value; maximum cannot be calculated, since the explicit mathematical form of the variation is unknown so far.

IN BRIEF

*A fairly good picture of the current trends in missile and spacecraft guidance control, was given by a recent ARS conference on these subjects. Seven of the most important technical papers presented at this conference—on trends in spacecraft digital computers, nuclear gyros, methods of optical heterodyning to derive the Doppler shift from solar and stellar radiations received by a moving vehicle, an extension of the Transit and Azusa principles to a new, more accurate navigation satellite, a new method of spacecraft attitude control, and the inherent limits in inertial and optical Doppler sensing—are excerpted in this report.*

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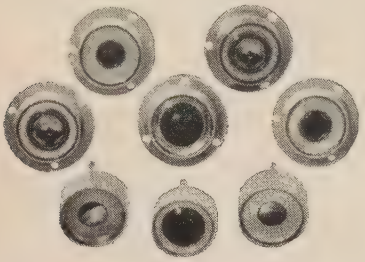

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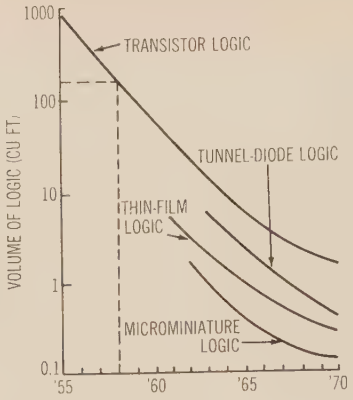


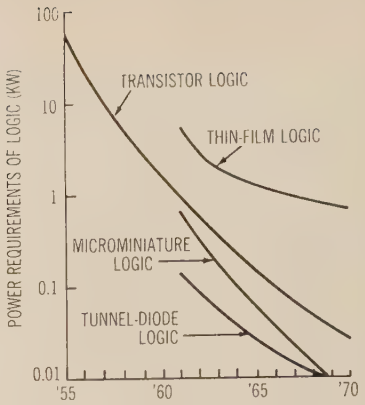


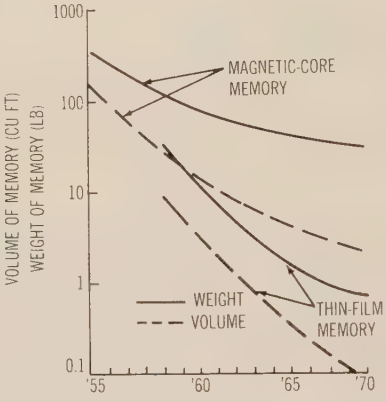


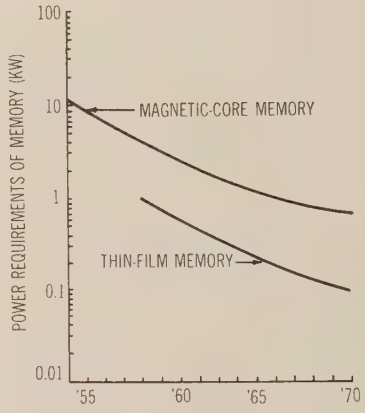


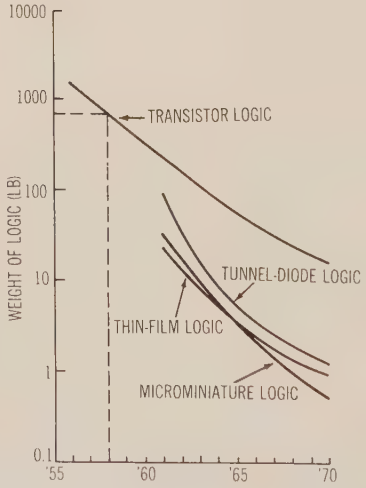


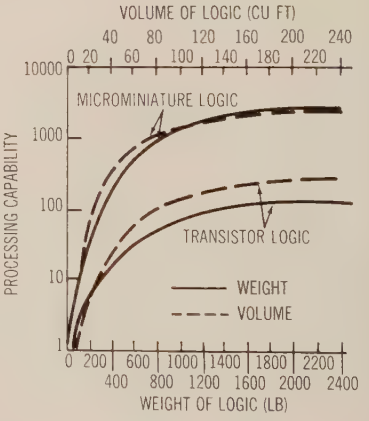


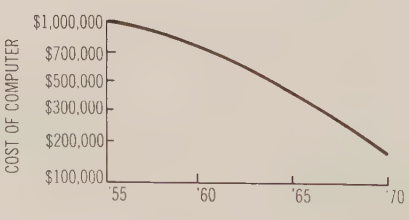


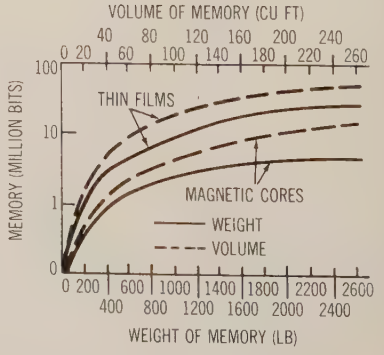

fourth of the total weight and volume of a logic section.

• Doubling the number of logic elements results in an increase of about 25 per cent in overall computer weight and volume.

The next decade's spaceborne computer, Khambata and Urban stated, will require the same memory capacity as that of today's large systems—about a million bits. However, the 1970 units will have about one-tenth the memory access time of today's systems, they predicted. Improved magnetic cores will provide the tenfold increase in speed of access. Thin films would be even faster, the authors asserted. Future systems will be cheaper, Khambata and Urban claimed, because as component operating speeds increase, fewer components will be needed.

Discussing nuclear gyros, W. H. Culver, of Rand, pointed out that though several attempts have been made to use the gyroscopic properties of sub-atomic particles for inertial reference, no one so far has demonstrated a practical device. As explained by Culver, the nuclear gyro operates on the principle that a sample of material, given a net alignment of its nuclei in a given direction, has a net nuclear magnetic moment that precesses about an externally applied magnetic field with the classical precessional angular frequency:

$$\Omega = \mu B/P,$$

where $\mu$ is the magnetic moment; $B$, the flux density of the external magnetic field; and $P$, the angular momentum vector.

◀ **FIGURE 1:** Volume, weight, power requirements, processing capability, and cost of spaceborne computers forecast for the next decade. Processing capability and cost are given in terms of a current large-scale, tube-type machine with a million-bit memory. The dashed lines in the graphs for the logic portion show one of the benchmarks from which the volume, weight, and power-requirement curves were plotted—they define the point representing a 1958-vintage computer with its processing capability increased 10 times. Such a computer would have had a logic unit taking up 150 cu in., weighing 800 lb, dissipating five kilowatts, and containing 40,000 transistors.

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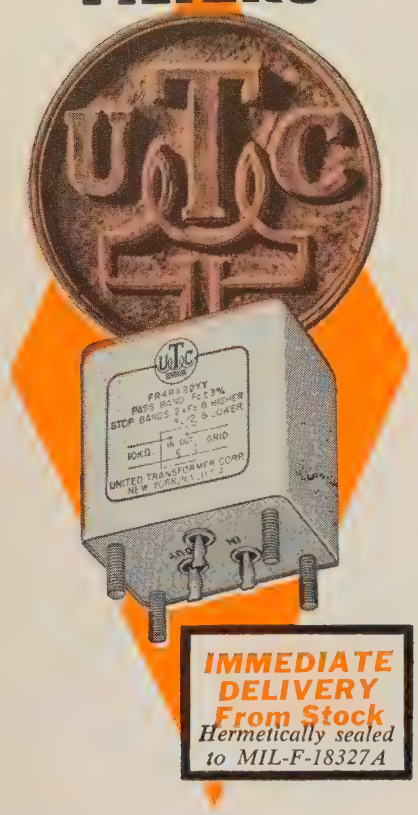

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BML band pass filters, similarly, work into a grid, but have an input impedance of 500/600 ohms. They provide a gain of 9.
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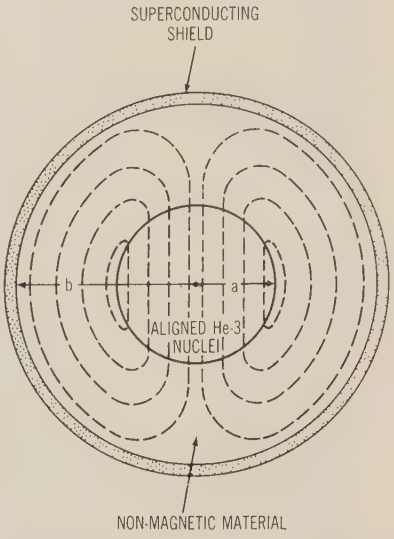


**FIGURE 2:** Magnetic field induced inside a superconducting shield of radius b by vertically aligned He-3 nuclei inside the sphere of radius a. The magnetic field inside the latter sphere is proportional to $1 - (a/b)^3$.

A particularly difficult problem of nuclear gyro design has been how to measure the alignment of the atomic nuclei without disorienting them. Another problem is posed by the need for particles with long relaxation times that will enable the "gyro" to retain its fixed orientation long enough to make practical.

Because of its relatively long relaxation time, Culver proposed the helium isotope of atomic weight three as the sensitive element of a nuclear gyro. The He-3 would be gaseous and enclosed in a superconducting shield to exclude all external magnetic fields. This shield would have to be made superconducting in such a way as to reduce the amount of the magnetic field trapped in the inhomogeneities of the material, Culver noted.

The alignment of the He-3 nuclei could be determined by forming the helium atoms into a beam and passing them through an inhomogeneous magnetic field, Culver sug-

**Table II: Limitations in Terrestrial Inertial Navigation**

| | Angular-Sensor Uncertainty (deg/hr) |
|---|---|
| Misalignment between axis of reference ellipsoid and geographic polar axis must be included in mechanization | $1.8 \times 10^{-4}$ |
| Migration of earth's pole must be included in mechanization | $5.4 \times 10^{-5}$ |
| Spin rate fluctuations of earth must be included | $1.7 \times 10^{-6}$ |
| Conventional earth-centered inertially non-rotating $X_i$—coordinate frame has an inertial angular velocity due to astronomic precession | $2.5 \times 10^{-6}$ |
| Inertial and sidereal spin rates differ | $10^{-6}$ |
| "Earth-centered inertial frame" has an inertial angular velocity viewed from an earth-satellite (Schouten-Thomas effect) | $2.4 \times 10^{-7}$ |
| Proper motion of stars is measurable | $3.3 \times 10^{-9}$ |
| Heliocentric, inertially non-rotating coordinate frame has an inertial angular velocity viewed from the earth (Schouten-Thomas effect) | $4.8 \times 10^{-10}$ |
| Ephemeris time is unsatisfactory; laws of dynamics are in question; error in value of astronomic precession | $10^{-11}$ |

| | Position Error (nm) | Accelerometer Threshold (g) |
|---|---|---|
| Geodetic information needed for alignment | 0.4 | $10^{-4}$ |
| Deflections of vertical must be mechanized en route | 0.05-0.4 | $1.3 \times 10^{-5} - 10^{-4}$ |
| Geodetic information needed to specify intercontinental distances | 0.11 | $2.2 \times 10^{-5}$ |
| Axes of reference ellipsoid not parallel to each other | 0.028 | $.5 \times 10^{-6}$ |
| Geodetic information needed to specify distances on land mass | 0.01 | $1.7 \times 10^{-6}$ |
| Ephemeris needed for navigation on earth | 0.005 | $10^{-7}$ |
| Acceleration of center of reference ellipsoid must be mechanized | 0.005 | $10^{-7}$ |

gested (*Fig. 2*). The beam would then be split in two, and the nuclei in each of the new beams would be counted to get the orientation information.

Another orientation scheme could use the anisotropic absorption of polarized 584-A light, by the aligned HE-3, Culver stated. In still another configuration—which would be simpler to build, according to Culver—the entire assembly, including superconducting shield, pickup coil, and He-3, would be rotated on bearings at angular velocity $\omega$. With the nuclei aligned along the axis of rotation, the pickup coil would not cut any of the flux lines (*Fig. 3*). However, if this axis itself were rotated from the direction of the nuclei by an angle $\theta$, the pickup coil would cut lines of flux, and these would induce within it an alternating voltage proportional to $\sin \theta$ at frequency $\omega$. The azimuth angle of the new orientation of the rotational axis would be proportional to the phase of the induced voltage.

A serious failing of this scheme, Culver admitted, is that the magnetic field due to the current flow in the pickup coil tends to precess the nuclei, thus disorientating them. To overcome this interaction

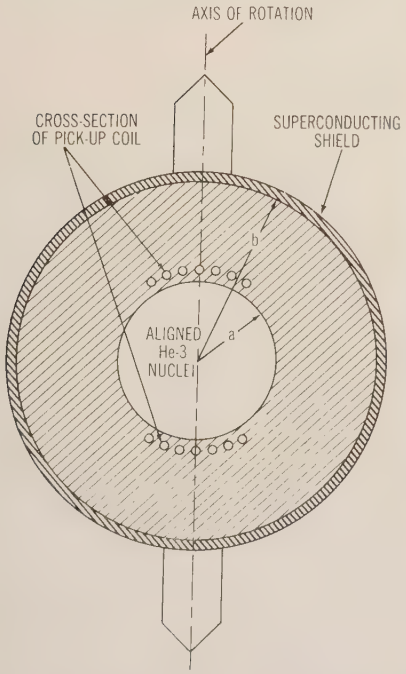


**FIGURE 3:** Cross-section of a rotating nuclear gyro proposed by Culver. If the He-3 nuclei are not lined up with the axis of rotation, they induce an electric signal in the pickup coil.

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Culver suggested the use of two identical pickup coils instead of one. The two coils would be turned at the same rate but in opposite directions to very nearly cancel out each other's magnetic field.

Three General Dynamics/Astronautics engineers proposed a navigation satellite system based on a combination of the techniques developed for the Navy's Transit satellite and the USAF Azusa missile tracking system. The proposals, the authors claimed, would reduce the computation load, observation time requirements, and boost system accuracy of a Transit-type system.

A microwave signal would be substituted for one of the VHF signals now sent from the Transit satellite. The other VHF signal would be used for aided frequency tracking and acquisition of the microwave signal. The latter, by providing more Doppler cycles with less ionospheric error than the VHF signal, would allow more accurate velocity measurements. The GD/A system would get additional accuracy by measuring the Doppler shift both passively (with the satellite transmitting to the ground receiver) and actively (with ground navigation transmitting to the satellite, which responds to the ground station). This double measurement would provide a relative frequency accuracy of $10^{-7}$, the authors maintained.

## Azusa-type sensing to find range

Satellite range would be determined by Azusa-type sensing of the phase delay of a modulated signal. A series of modulated signals would be sent out from the ground station to the satellite and repeated by the latter's transponder. The phase delay of the return signal would be measured, first at a low frequency and then at a frequency at least ten times higher.

Through sideband-folding, the satellite's receiver bandwidth would be made much narrower than that of conventional FM ranging systems. At a 10-kc bandwidth, the proposed ranging system could repeat modulation signals with frequencies up to five kilocycles directly and signals of up to 50 kc as a folded sideband. The range accuracy of the system would be about 50 ft.

The fundamental accuracy limitations of the optical Doppler

measurements in space navigation are due not to instruments but to variations in the light sources (sun and stars), it was stated by R. H. Horton and R. L. Wildey of JPL. The physical characteristics of these sources vary in such a way, Horton and Wildey said, that differences of ± 200 fps may be expected in the observed Doppler shift (*Table I*). Fundamental limitations also were discussed in a paper on inertial measurements by Myron Kayton, of Litton Systems, who presented figures on the limitations of angular sensors and position and acceleration sensing in terrestrial inertial navigation (*Table II*).

Template spectroscopy and optical heterodyning (with a laser as the local oscillater) as methods of measuring optical Doppler in space navigation were discussed by R. C. Franklin and D. L. Birx, of the Franklin Institutes Laboratory for R&D. Estimates for the template technique, based on the data acquired so far, indicate that relative velocity measurements down to the order of meters per second can be made from the sun's radiation.

In the heterodyning technique, a laser receiver would be used along with a laser local oscillator. The combination could produce a very-narrow-bandwidth signal in the RF ranges, according to the authors. For a mixer, a commercially available photomultiplier would suffice, they claimed.

One way of measuring velocity with this system would be to provide a feedback path to control the laser local oscillator frequency so that the input to the mixer is always kept a null, the Franklin researchers reported. The output of the feedback loop would then become the measure of velocity.

An attitude control system using three mutually perpendicular coils and the earth's magnetic field was described by A. G. Buckingham, of Westinghouse Air Arm Division. With current flowing in the coils and with the coils exposed to the earth's field, each would experience a torque of:

$T = BINA/(10 \sin \theta)$ *dyne-cm,*

where $B$ is the earth's magnetic field strength (in gauss); $I$, the coil current (in amperes); $N$, the number of turns; $A$, the coil area (in square centimeters) and $\theta$, the angles between the earth's and the coil's fields (in degrees). The direction of the torque would be such

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Model ST-300

IN ONE COMPACT 250 FORCE-POUND INSTRUMENT

FOR LARGE COMPONENTS AND SMALL SUBSYSTEMS . . . the new ITT ST-300 offers a 250 force-pound exciter for vibration *and* shock testing. This latest in a series of dynamic new vibration equipment utilizes the unique concepts of lateral motion excitation and air-bearing support—both developed by ITT engineering and proved on ITT's other vibration exciters of the 100 and 200 Series.

The exceptionally flat frequency response of the ST-300 permits precise testing without the need for elaborate compensating devices. Natural resonances are unaffected by table loadings. In addition, by checking shock *and* vibration on the same instrument, testing time and cost are substantially reduced. Other significant features of the ST-300 include:

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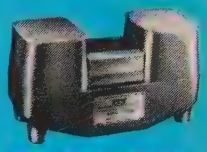

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No. 92 on Reader Service Card

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* Patent Pending

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as to cause the alignment of the earth and coil fields in a plane containing both field vectors.

In Buckingham's scheme, the three orthogonal coils are used as a torquing system for attitude stabilization. However, since the generated torque is always perpendicular to the earth's field, the system can generate torques in only two of the vehicle's control axes when the third is parallel to this field. Hence, an inertial wheel has to be added to the third axis—which actually means to all three axes, since the earth's field may be parallel to any one vehicle's three axes on some missions. For most applications, however, it appears that the inertia wheels can be omitted, Buckingham claimed.

W. C. Reisener, Jr., of the Franklin Lab for R&D, reported that his analysis shows a traveling-wave tube to be quite feasible as the mixer of an optical heterodyning system. For his studies, he had used a special electron tube consisting of a photosensitive cathode and a traveling-wave interaction structure. Interference of two optical signals at the photo surface produces a modulation of the emitted current at the beat frequency, he found. This beat signal can be coupled to a microwave receiver via a helical guide.

Reisener reported that he was able to obtain a wide bandwidth with a noise figure determined essentially by the characteristics of the photo surface. The noise contributions from other parts of the tube were negligible, the Franklin scientist said.

## References


*Papers at ARS Guidance, Control & Nav. Conf., Stanford U., Aug. '61: Khambata, Urban, "Space-Age Digital Computer—Components and Capabilities." ■ Culver, "Nuclear Gyros." ■ J. W. Crooks, Jr., R. C. Weaver, M. M. Cox, "Application of Sideband Folding Techniques to the Navigation Satellite System." ■ Horton, Wildey, "Fundamental Limitations to Optical Doppler Measurements for Space Navigation." ■ Kayton, "Fundamental Limitations on Inertial Measurements." ■ Franklin, Birx, "Optical Doppler for Space Navigation." ■ Buckingham, "A New Method of Attitude Control Utilizing the Earth's Magnetic Field for Long Life Space Vehicles." ■ Reisener, "Noise Consideration in the Design of a TWT Mixer for Optical Heterodyning."*

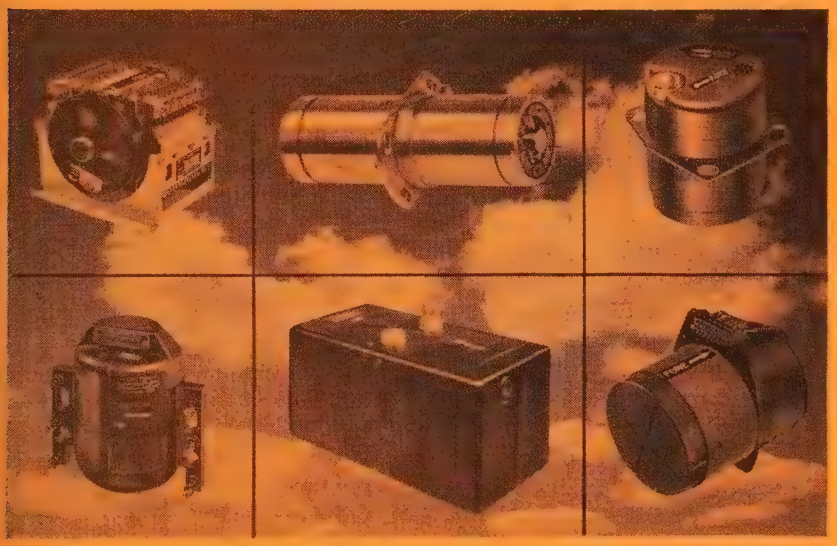



No. 93 on Reader Service Card

**FROM:** *Bendix Eclipse-Pioneer*

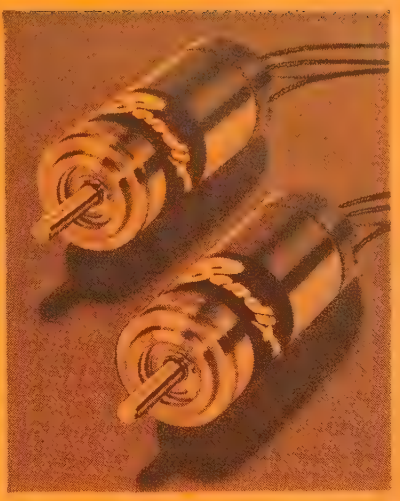
**SUBJECT:** *Aerospace gyros, synchros*

SIX LIGHT, RUGGED BENDIX GYRO TYPES MEET BROAD AEROSPACE NEEDS. With the Bendix gyro line, you enjoy a *double* benefit. First, *the line is unusually versatile*—includes models for a wide range of applications, such as radar stabilization systems, aircraft and missile guidance and control systems, bombing and navigational systems, and many others. Second, *high quality of manufacture is consistently combined with such advantages as light weight, proved accuracy, reliability, and ruggedness.*



Top: vertical; rate; and directional gyros. Bottom: free-cageable; two-gyro, three-axis (contains both vertical and directional units in a single package); and free-uncageable.

BENDIX GYROS FEATURE: Electrolytic switches for precise erection, long life • 1000-hour operating life • Two-gyro, three-axis control erection rate of 1.3°/min.—with normal erection rate of 2°/min. and fast erection up to 120°/min. for other models.



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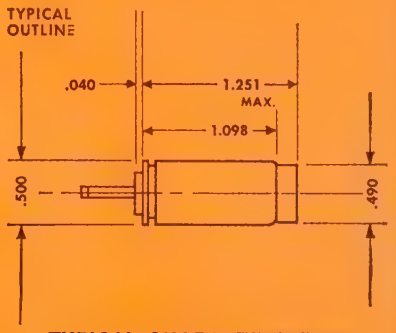


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No. 81 on Reader Service Card

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$$X^n + Y^n = Z^n$$

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Check Inquiry Form on Page 153

# S/A EMPLOYMENT INQUIRY FORM

November 1961 • Good until January 15 • Confidential • Not an application for employment

**THIS INQUIRY FORM** is designed to make it easier for you, our engineering reader, to explore employment opportunities in the aerospace industry.
Here is what you do:

- Tear out this page.
- Check off the organization(s) listed below that you would like us to contact. Please use a typewriter or pencil—ink will not reproduce.
- Turn the page over and answer the questions.
- Mail this form in a stamped envelope to:

Engineering Reader-Service Dept.
**SPACE/AERONAUTICS**
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We will promptly forward a copy of your inquiry form to each of the organizations you specify. If your experience and background matches their requirement, they will get in touch with you at your home.

I am interested in the employment opportunities at:

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- ☐ General Dynamics/Astronautics 161, 162, 163, 164
- ☐ General Electric Co., Defense Systems Div. 159
- ☐ Jet Propulsion Lab., Calif. Inst. of Technology 152
- ☐ Johns Hopkins University, Applied Physics 166
- ☐ Kearfott Div., General Precision Inc. 165
- ☐ Litton Data Systems 81, 158
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- ☐ Lockheed California Div. 191
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- ☐ McDonnell Aircraft Corp. 155
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- ☐ United Aircraft Corp., Pratt & Whitney Div. 157

Some of the recruitment advertising in this month's issue of SPACE/AERONAUTICS may have arrived too late for listing. In such cases, just note the name of the organization and page on which the ad appears. Please refer only to this month's ads that direct you to this Inquiry Form.

Name of organization _____ _____

Page on which ad appears _____ _____

NOTE: If you have an immediate interest in any special employment advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We would appreciate it if you would mention SPACE/AERONAUTICS in your covering letter.

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Please type or print

**FIELDS OF INTEREST**—note the general fields in which you would like to work (e.g., basic research, dynamics, structures, propulsion, electronics, testing, production, ground support, etc.):

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**SPECIALIZED ENGINEERING EXPERIENCE**—describe specific technical areas in which you have worked:

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**EMPLOYMENT**—where are you now working and for whom did you work before that?

| | | |
|---|---|---|
| Employed by 1._____ | 2._____ | 3._____ |
| City & State _____ | _____ | _____ |
| Years_____to_____ | _____to_____ | _____to_____ |
| Title or Job Function _____ | _____ | _____ |
| _____ | _____ | _____ |

**DEGREES**—list your college and university degrees:

| | | |
|---|---|---|
| School_____ | _____ | _____ |
| City & State_____ | _____ | _____ |
| Years_____to_____ | _____to_____ | _____to_____ |
| Degree_____ | _____ | _____ |

**SPECIAL TRAINING:** Briefly describe any special industry, military, or scholastic training:

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**PERSONAL DATA:**

Name_____ Age_____

Home Address_____ Home Phone_____

City & State_____ U. S. Citizen ☐ Yes ☐ No*

* If not, when do you expect to become a citizen?_____

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to SPACE/AERONAUTICS.



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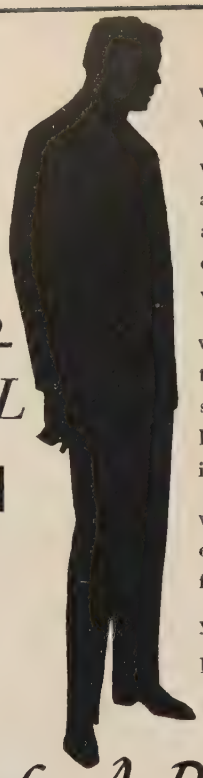

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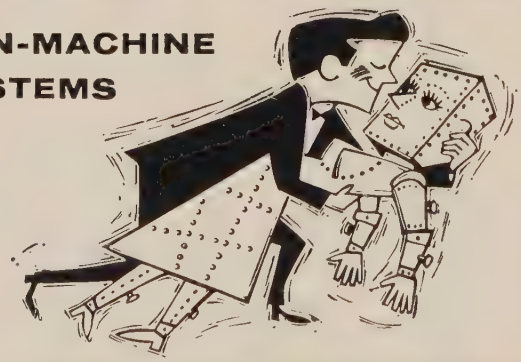

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Write in strict confidence to Mr. P. W. Christos, Div. 60-MK, DEFENSE SYSTEMS DEPARTMENT, General Electric Company, Northern Lights Office Building – Syracuse, New York

DSD DEFENSE SYSTEMS DEPARTMENT
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GENERAL ELECTRIC

*Using the hypothetical example of a 412-L system covering Australia alone, a rough approximation of the airspace to be managed may be arrived at by multiplying the continent's area (roughly, 2.97 million miles) by the 9.4 miles of altitude within easy reach of today's aircraft.

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# Outstanding Missile and Space Openings for Electronic/Electrical Engineers

The Boeing Company, system contractor on the Dyna-Soar manned space glider and weapon system integrator on the solid-fuel Minuteman ICBM, has a number of immediate openings for graduate Electronic/Electrical engineers. These positions, available in areas described below, offer challenge and scope, and exceptional opportunities to advance to higher levels of responsibility and income.

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**Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.**

**Although not an application for employment, it provides employment managers with information to evaluate your capabilities—and in turn give your request immediate consideration.**

**Check the "Employment Inquiry" form for details.**



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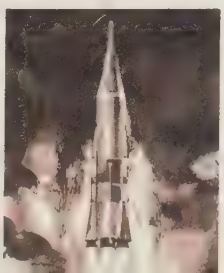
# COME TO LIFE

# ENGINEERS & SCIENTISTS

Engineers and scientists at General Dynamics | Astronautics enjoy not only the immeasurable rewards of participating in the development of this nation's most advanced space systems, but also the added bonus of living and raising their families in resort-like San Diego, California. San Diego's climate is near-perfect, and its ideal location permits almost any sort of family recreation the year around. Indeed, on the first day of summer last year, the temperature was 78 degrees; on the first day of winter, 76. Schools are excellent and uncrowded; cultural attractions are abundant; advanced educational facilities are constantly being expanded.

If you are an experienced engineer or scientist, just a cut above the average, we'd like to tell you more about our company, our community, and how both might fit into your future. You'll find more information on the back of this page. There is also a convenient inquiry card which will receive immediate and confidential attention. Why not mail it today? No obligation, of course.

*If the inquiry card has been removed, or if you wish to furnish or request more detailed information, please write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Mail Zone 130-90, General Dynamics | Astronautics, 5704 Kearny Villa Road, San Diego 12, California. (If you live in the New York area, it may be more convenient to contact Mr. T. Cozine or Mr. E. Hart, General Dynamics | Astronautics, One Rockefeller Plaza, New York City, Telephone CIrcle 5-5034.)*



GENERAL DYNAMICS ASTRONAUTICS

FORMERLY CONVAIR/ASTRONAUTICS

# ENGINEERS AND SCIENTISTS

General Dynamics | Astronautics is located in San Diego, California, one of the fastest growing communities in the United States. It is situated 10 miles north of the Mexican border and a little over 100 miles south of Los Angeles.

Immediate openings exist in the following areas:

**SCIENTISTS & ANALYTICAL ENGINEERS** with Ph.D. or Sc. D for electronics and physical research; computer analysis and application; and instrumentation development.

**ELECTRONIC DESIGN & TEST:** communication systems and data transmission design; logical circuitry; automatic control systems; and electronic packaging. BSEE plus appropriate experience required.

**MECHANICAL DESIGN:** BSME or AE for pneumatics, hydraulics, and fluid systems design and test. Also missile GSE and missile structures designers.

**RELIABILITY ENGINEERING:** San Diego openings exist for experienced engineers with applied higher mathematics education, preferably in statistics; higher degrees preferred. Circuit analysis with transistor and diode experience is also desirable.

**ENGINEERING WRITERS** with 2 years' college and 3 years' experience in preparation of TCTO's; operations, maintenance, and overhaul manuals.

**SYSTEMS ENGINEERING:** BS degree required, a vanced degree desired, in engineering or related fiel Two to five years of experience, including missile similar background in testing, methods of operatio systems analysis, and evaluation. Assignments will i clude establishment of test requirements, determin tion of factory tolerance structures, and evaluatio of field testing.

**GUIDANCE SYSTEM ANALYSTS** to define the op mum characteristics, philosophy, and mode of oper tion of sophisticated guidance systems of extrem accuracy. A Ph.D degree plus experience in guidan systems and missile simulation is desired, but mo extensive experience in related fields will be favorab considered.

**PRE-DESIGN ENGINEERS** with experience in pr posal preparation and system design of guidance an tracking systems.

If you desire to become part of this great team, w urge your prompt inquiry on the attached Profession Placement Inquiry.

*Technical openings also exist in other specialtie Write Mr. R. M. Smith, Industrial Relations Admi istrator-Engineering, Dept. 130-90, General Dynan ics | Astronautics, 5704 Kearny Villa Road, San Dieg 12, California. (If you live in the New York area, may be more convenient to contact Mr. T. Cozine Mr. E. Hart, General Dynamics | Astronautics, O Rockefeller Plaza, New York City, Telephone CIrc 5-5034.)*

AN EQUAL OPPORTUNITY EMPLOYER

GENERAL DYNAMICS ASTRONAUTICS

FORMERLY CONVAIR/ASTRONAUTICS

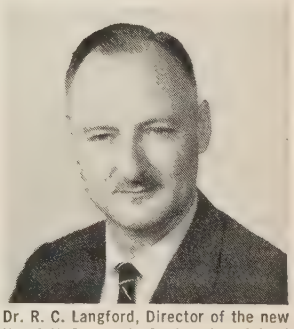
A Message Directed to Engineers and Scientists Who Have Received Their Doctoral Degrees and are Recognized Authorities in Their Fields

# KEARFOTT ANNOUNCES THE ESTABLISHMENT OF A NEW RESEARCH CENTER FOR THE AEROSPACE SCIENCES

*under the direction of Dr. Robert C. Langford*

To meet accelerating national goals in space, upper atmosphere flight and undersea defense, radical advances in many technologies are essential. Kearfott, long a leader* in the development of systems and components for control, navigation and guidance, is preparing to enhance its endeavor in these and allied areas, through a multidisciplinary program of Applied Research. To this end, the new Research Center has been established. It will complement but not duplicate discrete R&D activities of the 26 Kearfott laboratories now functioning within the company's 8 Engineering Divisions.

*20 Kearfott precision instrument devices played a part in recent successful space flights of America's astronauts.



Dr. R. C. Langford, Director of the new Kearfott Research Center, has joined Kearfott after 18 years as R&D Director in a major electronics corporation. He was graduated with a Doctorate as a Swan Research Fellow from the University of London. He is senior member of IRE, a founder member of the American Nuclear Society and a member of the American Rocket Society. An author of technical articles and lecturer, he has also been a member of a U.S. Government committee analyzing Russian accomplishments in the electronic and solid state fields.

## Dr. Langford Details Kearfott Philosophy of New Center

***"This will be a scientific community entirely concerned with scientific and technical investigations; totally divorced from administrative or development responsibilities.***

***"Principal Staff Scientists will report to the Director—without any intervening 'level-of-command' to obscure a research man's ideas."***

**THE CENTER'S METHOD OF PROBLEM-SEEKING** "Study areas will be related as closely as possible to urgent government needs. Senior members of the staff will seek, in conjunction with government scientists and other personnel, to determine the most difficult problems requiring solution (particularly but not exclusively, in control, navigation and guidance areas). It will then be up to the Center scientists to formulate appropriate investigations."

**RESEARCH RESPONSIBILITY** "The individual will guide his own research, calling upon Center resources for any technical assistance he requires. (Successful concepts will be carried to the prototype stage by Kearfott's engineering organization, without close supervision by the scientist, who may turn to other problems)."

**CONSULTANTS IN LEADING INSTITUTIONS** "Arrangements have been made for consultation with outstanding authorities at universities and foundations in this country and abroad. A stimulating cross-fertilization of ideas is projected, both with colleagues here and outside the Center."

**SERVE ON DOD COMMITTEES** "In the national interest, Center scientists will themselves feel free to act as consultants to agencies of the government and serve as desired on committees of the Department of Defense or other national agencies as independent authorities."

**TECHNICAL INFORMATION SERVICES** "A comprehensive collection of classified and unclassified technical source material will be available as well as the services of professional librarians to make library searches.

"Other facilities include excellent laboratory equipment, access to computer and data processing services; private quarters will be provided as soon as the RESEARCH CENTER building is completed in the summer of '62."

**MEN WITH SCIENTIFIC VISION...** and a touch of the missionary spirit that plays a significant part in building a research capability of this order, are invited to inquire about key appointments now open in areas indicated at the right. (A doctoral degree, and at least eight years research experience, is mandatory).

**Oceanography** — to investigate natural phenomena, in order to arrive at a more perfect understanding of the effect of earth sciences on systems required by government. (A vessel will be provided)

**Radiation Sciences** — to increase understanding of plasmas, wave propagation; to fully explore energy conversion and infrared technologies.

**Astrospace Environments** — to study natural phenomena in order to provide a more perfect understanding of environmental boundaries of space systems.

**Hydraulics & Pneumatics** — to provide a fuller understanding of fluid technology in dynamic systems.

**Guidance & Navigation** — Terrestrial and Celestial — to develop a broader comprehension of the needs of future systems.

**Physics** — Specialist in Modern Materials research pertaining to solid state, fluid, magnetic and dielectric materials.

**Chemistry** — to develop and extend range and application of organic and inorganic materials. Activity will be in both materials and processes.

**Metallurgy** — to serve as authority on metallurgical properties of Modern Materials — function-wear, defect propagation and anelasticity.

*Please write Dr. Langford at some length about your interests and past work. Copies of papers written or presented will be appreciated —and returned, if desired.*

**KEARFOTT** DIVISION
**GENERAL PRECISION, INC.**

Dept. 2A • 1150 McBride Ave. • Little Falls, New Jersey

*An Equal Opportunity Employer*

Check Inquiry Form on Page 153

Check Inquiry Form on Page 153

# DEVELOPMENT ENGINEERS

## Advanced Motors, Generators, Solid State Circuit Design

Several fine opportunities are now available in expanding project areas.

### Generator Development Engineer

This position requires a man for design and development work on high speed alternators. A comprehensive knowledge of alternator design is needed with special emphasis on high speed, high frequency machines. BSEE and 3-5 years experience required.

### Development Engineer for Advanced Motors

Prefer physicist, or EE, for work involving electromagnetic theory as applied to advanced electric motor studies. This work involves investigation of electrical, thermal and mechanical phenomena, with immediate assignment dealing with solid rotor motors.

Work will involve machine studies using modern computer techniques. Requires 3-5 years experience.

### Development Engineer for Solid State Circuit Design

This work involves design and development of solid state power conversion equipment. Experience is needed in the operation of silicon controlled rectifiers in power handling circuits. Requires BSEE and 3-5 years experience.

U.S. citizenship or previous secret clearance required. Garrett is an "equal opportunity" employer. Send complete resume to Mr. Thomas Watson.

GARRETT

**AIRESEARCH MANUFACTURING DIVISION**

*9851 So. Sepulveda Blvd., Los Angeles 45, California*

Check Inquiry Form on Page 153

ENGINEERS
PHYSICISTS
MATHEMATICIANS

# SYSTEMS EVALUATION POLARIS SYSTEM

*The Applied Physics Laboratory of The Johns Hopkins University has responsibilities in the evaluation of the Polaris Missile System. We invite you to consider the following career appointments:*

**Senior Mathematicians**

*Duties will involve statistical analysis of complex test data for performance, reliability and operation evaluations. A background in physics or electrical engineering is desirable.*

**Project Engineers**

*For field test operations involving a team effort of Contractor, Navy and APL Personnel. Work will include launch and flight data acquisition analysis and monitoring of shipboard activities related to the Polaris Missile System. Prefer engineers with considerable background of project level responsibilities.*

**Systems Engineers**

*APL has several positions available on the associate and senior levels for men with experience in electrical engineering, physics, mechanical engineering, dynamics, or computer engineering. Will perform systems work related to fire control, navigation, missiles, and submarine controls. Assignment involves field work and contact with the Navy and Contractor Personnel.*

**Systems Analysts**

*Respondents must have heavy theoretical background and ability to read and understand telemetry records. Will perform basic analysis of systems related to fire control, navigation, missiles, and submarine controls. May also be required to simulate and solve orbit and doppler equations. Associate and senior level appointments.*

**Data Requirements, Instrument Engineers**

*Positions require a physicist or electrical engineer with experience in evaluation, data acquisition and testing of instrumentation installations. Will analyze sub-systems such as guidance, propulsion, controls, boosters, and inertial systems individually and as integral parts of over-all systems to derive data requirements and instrumentation. Duties involve some field work.*

*APL will provide you with a professional atmosphere conducive to creative effort as well as the tools and technical support required to tackle these and related problems. Our facilities are located in Silver Spring, a residential suburb of Washington, D. C., offering you a choice of country, suburban or city living.*

**For additional details, direct your inquiry to: Professional Staff Appointments**

The Applied Physics Laboratory
The Johns Hopkins University

**8617 Georgia Avenue, Silver Spring, Md.**

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Check Inquiry Form on Page 153

# AIRCRAFT ENGINEERS

## *THIS* is an Invitation

. . . to join us here where there is a future for you second to none. Here our projects include Giant C-141 jet transports . . . Intercontinental C-130 turbo-prop transports . . . JetStar passenger craft . . . "Hummingbird" type VTOL aircraft . . . Missiles . . . Rockets . . . Nuclear Products . . . Nuclear Research . . . Avionics Research . . . Operations Research . . . Cryogenics Research . . . and scores more interesting long-range projects.

*Openings in the fields of:* Aircraft Design Engineering • Engineering Drawings Checking • Aircraft Structures • Basic Loads • Flutter and Vibration • Sound and Vibration • Aircraft Specifications Engineering • Reliability Engineering • Operations Research • Aircraft Research Engineering.

*Write to:* Hugh L. Gordon, Professional Employment Manager, Lockheed-Georgia Co., 834 W. Peachtree St., Atlanta 8, Georgia. Department DD-76.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

## THE ENGINEERING CENTER

**LOCKHEED-GEORGIA COMPANY**

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

Check Inquiry Form on Page 153

# DESIGN DEVELOPMENTS

*For more details on the equipment, processes, and facilities described in this section,*

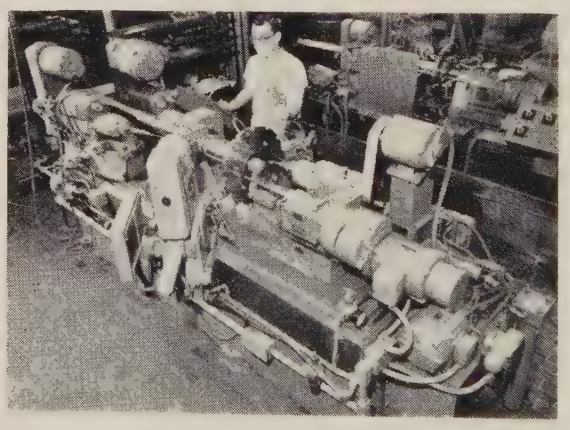
## EXPLOSIVE FORMING UNDER DEVELOPMENT AT MARTIN

Explosive forming of finished shapes from high-strength steel or refractory metals at The Martin Co., Baltimore, Md., is expected to reach production status next year. The main advantage of the process, says Martin, is that it eliminates much of the welding footage formerly necessary to fabricate large parts.

To fabricate a part, a die is made, and a charge of the explosive is laid out conforming to the shape of the preform. The charge is suspended in water within the die. Its detonation forces the metal into the final shape.

The charges range from blasting caps to several pounds of high explosives. They can be shaped into tube, rod, ball, or sheet forms. Metal clamps around the edge of the die ensure a tight seal for drawing a vacuum into the die during the explosion.

## One Machine Setup To Fabricate 42 Holes



A precision machine that can drill, ream, and bore has been designed by Pratt & Whitney Aircraft Co., East Hartford 8, Conn. It requires only one setup for the entire operation, in which 42 holes are fabricated in the turbine shaft of a jet engine. In addition to reducing setup time and manpower requirements, it also cuts down on machining time.

P&WA used a 10-ft bed pattern and standard drilling heads. A stock indexing head was reground to the accuracy required by the engine specs. The index plate of the machine is bolted directly to the part and positioned with a pin. (Ordinarily, this plate is located on the machine and connected to a series of drive mechanisms.)

The pneumatic-hydraulic machine forms 36 holes in the shaft flange and eight angular holes in the shaft journal. Hole locations are held to 0.001 in.

## Cheaper Glass-Metal Sealing Ups Quality

A new processing technique that considerably improves the quality of glass-to-metal seals and cost, too, has been developed by Electron Technology, Inc., Kearny, N.J. Metal parts are chromallized and then oxidized. The resultant oxide film both wets the glass to achieve an intimate bond and protects the metal substrate from further oxidation during the sealing and heating cycle.

With this method, both soft and hard glass seals can be formed in air by conventional glass-blowing techniques. No carefully controlled atmosphere or other special control is needed to prevent over-oxidation of unprotected molybdenum. **53**

# Materials and Production

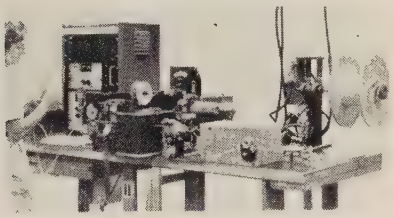
*write in item numbers on Reader Service Card*

## Carbon Insulation Stops Erosion, Too

After two years of R&D, H. I. Thompson Fiber Glass Co., 1733 Cordova St., Los Angeles 7, Calif., has developed "Hitco-C", a carbon product useful as both thermal insulation and erosion barrier. Hitco-C has undergone successful firing tests and is already being used in a number of rocket components.

Combined with phenolic resin, Hitco-C—which is virtually pure carbon—offers low thermal conductivity and a low ablation rate. It is compatible with most resin systems and reinforced-plastic fabrication techniques. The manufacturer expects it to prove particularly effective in filters for corrosive liquids and vapors, as electric insulation, and in dry-nonlubricated bearings. Produced in fiber form and fabric rolls, it has a warp breaking strength of 25 lb/in. **54**

## Wire-Numbering Machine To Save $70,000+ per Year



Five new Lockheed-designed automatic wire-numbering machines will replace seven numbering machines now used at the company's California division. Savings for the first year are estimated at $70,000 plus.

No companion linotype machine is required as with previous wire-numbering equipment. Numbers and letters—as many as 18—are dialed directly on steel disks, which maintain printing temperature. Changes in type are a matter of three or four seconds.

The machine prints with gradual and adjustable pressure, rather than impact, saving wear. Variable spacing is pre-set to conform to military specifications or other requirements. An "electronic brain" maintains control over spacing of numbers, quantities of wires, and cut-off cycle. If knots or kinks occur in wiring, the machine automatically shuts itself off.

The new design "flip-flops" the wire to print on each side alternately, saving one complete set of type, one roll of marking foil, and approximately half the cost. All sizes and types of wiring, from miniaturized 22 gage and standard 10 gage to heavy coaxial cable, can be accommodated.

Operating speed is 23 per cent above previous performance and is expected to be even greater with development of a device to coil wire automatically after printing. The present rate is 646 inches per minute. IBM card control is projected for the future.

The American Pacific Stamp Co., 1523 E. Washington St., Los Angeles, Calif., is licensee for manufacture and sale of the new machine. **55**

**FILTRATION KIT**—A filtration kit which was designed for laboratory work in ultra fine filtration and contamination analysis of liquids has been found to be equally useful in certain lubrication applications, says Bearing Inspection, Inc., Dept. S/A, 3311 E. Gage Ave., Huntington Park, Calif. Examples of this use include ball and roller bearings in servos, gyroscopes, and tape transports.

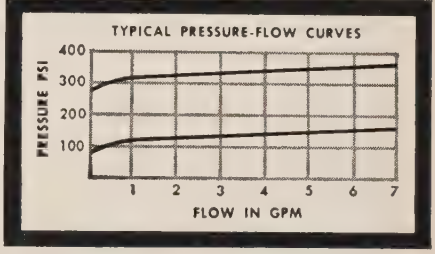
No. 266 on Reader Service Card


**For Precise Control of Pressurized Fluids . . .**

**Reliable Cartridge RELIEF VALVE**

- **Eliminates connectors, fittings and lines.**
- **Reduces leakage points.**
- **Simplifies maintenance.**
- **Reliable.**
- **Noiseless.**

• Simplified circuitry, reduced weight and greater design freedom are other advantages offered by this direct acting relief valve. Used in a multi-stage manifold, this valve can be removed without disconnecting any lines. It is just one of many fluid flow and pressure control valves Fluid Regulators has designed and manufactured to meet exacting specifications.




**SPECIFICATIONS:**

- **Operating Pressure: Three ranges 75 - 500 psi**
- **Burst Pressure: Above 5,000 psi**
- **Cracking Pressure: Externally adjustable**
- **Internal Leakage: Drops per minute**
- **External Leakage: Zero**
- **Fluids: All fluids compatible with stainless steel and anodized aluminum**
- **Temperatures: —65°F. to +275°F.**
- **Weight: 6 oz.**
- **Part No.: 7385**

This valve can be furnished with a body and to meet user's pressure and flow requirements.

*Write for detailed literature*

**Fluid Regulators CORPORATION**

**313 Gillette Street • Painesville, Ohio**
**ELmwood 2-3319**

No. 94 on Reader Service Card

# Westinghouse Electric Power System

Electric power is the lifeblood of flight vehicles.

Instrumentation, control, guidance and navigation, communication, human comfort—indeed virtually every function in every modern transport, military or civil aircraft, missile or space vehicle depends on an electric power system.

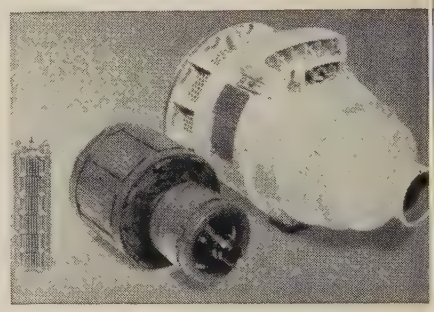
For many years Westinghouse has specialized in the design and production of such systems. These have ranged from wind-powered generators of World War I aircraft to today's superb brushless generators and static control equipment.

Headquarters for this important activity is the Westinghouse Aerospace Electrical Department at Lima, Ohio.

Here more than 1600 skilled men and women design, develop and produce airborne electrical equipment which has achieved an unrivaled record of trouble free service.

Here, too, skilled scientists and engineers are working on new systems to meet electrical requirements of flight in years to come. This work is directed by R. W. Esarey, AED manager (left seated), A. L. Paquette, marketing manager (seated), J. D. Miner, engineering manager, and F. W. Lowry (right standing), manager of advanced systems applications.

One of the most successful flight proved electric power systems ever built consists of 30 and 40 KVA brushless generators and static control apparatus for the Boeing commercial Jetliners. Mean time between removals is in thousands of hours — a dependability record many times better than that of ordinary brush-type generators.

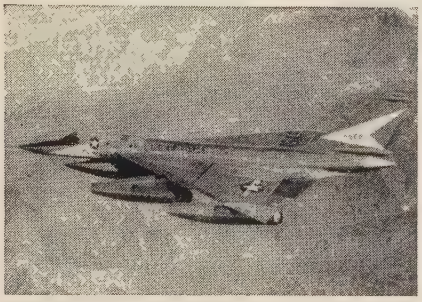


Longer service life and greater reliability results from the elimination of commutators, carbon brushes, and collector rings. These are replaced by a single rectifier stack consisting of high-temperature silicon diodes. Westinghouse research in semiconductors made this important advance possible. Results: greater reliability, increased TBO, reduced maintenance costs.

# erve the Advancing Needs of Flight

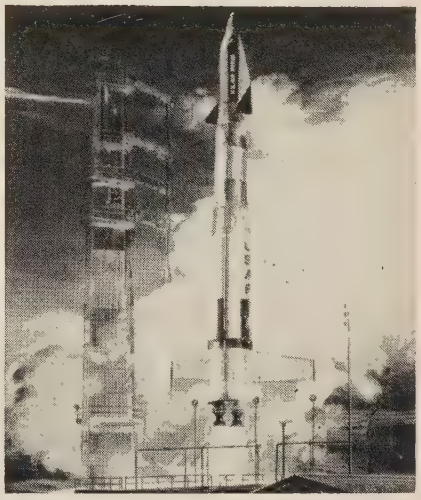
Westinghouse brushless generators are standard on Boeing 707s and 720s. The coming 3-engine Boeing 727, above, will have a new Westinghouse starter-generator system using the basic, time-proved brushless design.

The largest rated brushless air-cooled generators ever produced supply electric power for the Air Force B-52H, built by Boeing. These Westinghouse generators are rated at 120 KVA.



Oil-cooled brushless generators are provided for two major high-performance military aircraft, the Air Force B-58 "Hustler," built by Convair, and the Navy A3J, built by North American Aviation.

Another military aircraft, the sleek Air Force T-38 Jet Trainer, built by Northrop, is equipped with Westinghouse 8 KVA brushless generators.



Space electric power systems also are a major activity at Westinghouse. The Air Force manned space glider, Dyna-Soar, to be built by Boeing, will have a new brushless generator and static control equipment to supply vital electric power.

For the future, thermoelectric, thermionic, solar cells of high efficiency, magnetohydrodynamic and other advanced systems are being developed to provide electric power for space as well as non-space applications.

*You can be sure . . . if it's*

**Westinghouse**

J-02339

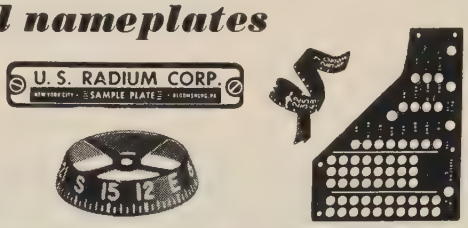
No. 95 on Reader Service Card

# U.S. Radium presents...

## dials, panels and nameplates

Edge-lighted Lackon® panels
Embedded circuit panels
Screen-marked tapes
Lithographed and etch-marked dials, panels and nameplates/Bulletin 10.30 B

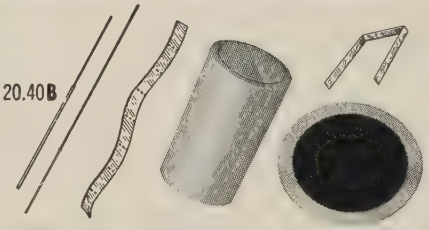
No. 96 on Reader Service Card




## radiation sources

Sealed beta, gamma and neutron sources/Bulletin 20.40B
Ionization sources for electron tubes/Bulletin 13 B
Alpha calibration sources/Bulletin 20.80 B
Tritium foils and targets/Bulletin 20.70 B

No. 97 on Reader Service Card



## isolite light sources

Radioisotope-excited, self-luminous markers, signs, placards, etc./Bulletin 30.31 B
Tritium-excited luminous compounds
U.S. AEC byproduct material license No. 37-30-6 (C 63)

## phosphors

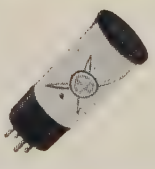
Undark® self-luminous compounds/Bulletin 1.1P B
Helecon phosphorescent and fluorescent pigments/Bulletin 65-600 B
Radelin® cathode ray tube phosphors/Bulletin 40.61 B
Thermographic phosphors/Bulletin 40.40 B
Electroluminescent phosphors/Bulletin 50.10 B
Product identification phosphors/Bulletin 40.50 B

No. 99 on Reader Service Card

## geiger-mueller tubes

In stock—highest quality, economically priced G-M tubes distributed exclusively in USA for Electronic Associates Limited of Canada /Bulletin EAL B

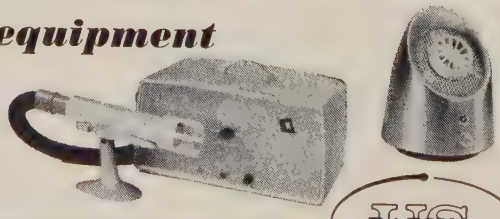
No. 100 on Reader Service Card



## ion generating equipment

Selective ion generators/Bulletin 60.30 B
Dynamic Ionaire® Mark VII negative ion generator/Bulletin 60.23 B

No. 101 on Reader Service Card



US RADIUM

## united states radium corporation

MORRISTOWN, N. J. | Offices: Chicago, Illinois and North Hollywood, Calif. Subsidiaries: Radelin Ltd., Port Credit, Ont., Canada and U.S. Radium Corp. (Europe), Geneva, Switzerland.




**POLYETHYLENE** – A polyethylene compound specifically designed for thin-walled cellular primary insulation, Bakelite DGDA-2580, is said to be tougher than previously available plastics for cellular extrusion. At 30 per cent cellular composition, the new polyethylene developed by **Union Carbide Plastics Co., Dept. S/A, 270 Park Ave., New York 17, N.Y.**, has higher tensile strength than solid polyethylene insulation.

No. 267 on Reader Service Card

**PLASTICS**—Two reinforced plastics made with asbestos base and proprietary phenolic resins have been developed especially for use in rocket components, says **Taylor Fibre Co., Dept. S/A, Norristown, Penna.** These plastics are known as Tayloron PA and Tayloron PA-6. They have excellent thermal insulation, heat resistance, good ablation performance, high tensile and flexural strength, and good impact resistance.

No. 268 on Reader Service Card

**WELDER**–An electron beam welder, Model VX-20-30-48, employs a vacuum chamber that measures 20 in. wide by 30 in. high by 48 in. long. This rectangular design affords maximum geometrical space, says **Sciaky Bros., Inc., Dept. S/A, 4915 W. 67th St., Chicago 38, Ill.** The electron gun is provided with traverse and vertical motion powered by a speed and position servo-control. The vacuum chamber is pumped to 1 x $10^{-4}$mm. Hg in about four minutes. The pumping sequence is fully automatic.

No. 269 on Reader Service Card

**MOBILE COBALT UNIT**— Directional or panoramic industrial inspection can be performed with this 150-curie mobile cobalt unit recently introduced by **Picker X-Ray Corp., Dept. S/A, 1275 Mamaroneck Ave., White Plains, N. Y.** It is reported to be ideal for foundries and steel fabrication in high production radiography of heavy sections. The unit is available either in mobile hydraulic mount, or a rugged A-frame.

No. 270 on Reader Service Card

**CYLINDER BORER**—This vertical cylinder boring machine includes a horizontal slide for finish facing of crankshaft thurst faces, according to **Ex-Cell-O Corp., Dept. S/A, 1200 Oakman Blvd., Detroit 32, Mich.** This two-way unit is said to effect great savings because the facing operations are performed simultaneously with the finish boring of the cylinder bores.

No. 271 on Reader Service Card

No. 142 on Reader Service Card

*Materials and Production*

**CHILLING UNITS** — Heavy duty chilling units, designed for use in stabilization and precipitation hardening, are being modified to chill quantities of stainless steel down to —120 deg F. According to **Cincinnati Sub Zero Products, Dept. S/A, 3932 Reading Rd., Cincinnati 29, Ohio,** their model ST-120-15 measures 36 x 24 x 30 in., has a capacity of 4000 BTU/hr at —120 deg F, and will chill 200 lb of steel per hour from ambient to —120 deg F.

No. 272 on Reader Service Card

**PROTECTIVE SLEEVE** — A silicone coated, fiberglas material is being used to make pliable, accordion, protective sleeves. **A & A Mfg. Co., Inc., Dept. S/A, 712 S. 12 St., Milwaukee 4, Wisc.,** says that this material resists temperatures to 450 deg F, and flexes normally at —80 deg F. During a 70-hour test, volume change did not exceed 11 percent. These sleeves are recommended as ducts for heat and hot gas transfer between intake and exhaust of industrial furnaces.

No. 273 on Reader Service Card

**PORTABLE WELDER**— A compact, portable machine that can be used to stress relieve up to 12 welds at a time and to do a-c/d-c welding has been introduced by **Electric Arc, Inc., Dept. S/A, Newark, N. J.** Designated the UniPak, it is available in two models—one with six heating control units and the other with three. The six-unit machine can relieve up to 12 welds at one time in 3-in. diameter pipe, and up to 6 welds in 6-in. pipe.

No. 274 on Reader Service Card

**PYROLYTIC GRAPHITE**—Pyrolytic graphite that polarizes infra-red light is available in plates, cylinders, and special shapes. The material is produced as a coating for plain graphite and other materials in sizes up to 4½ ft. in length, according to **General Electric Co., Dept. S/A, Detroit 32, Mich.** Impermeable to gases and liquids, the material has possible applications in the nuclear power field, as a gas barrier around fuel elements.

No. 275 on Reader Service Card

**ADHESIVE**—A room temperature curing adhesive for service at 400 deg F. is announced by **The Epoxylite Corp., Dept. S/A, 1428 N. Tyler, South El Monte, Calif.** The material designated Epoxylite 810, is a two component system consisting of an epoxy paste and a powdered curing agent. The new adhesive provides excellent adhesive strength, and maintains good adhesive properties for service in excess of 200 hours at 400 deg F.

No. 276 on Reader Service Card

No. 169 on Reader Service Card

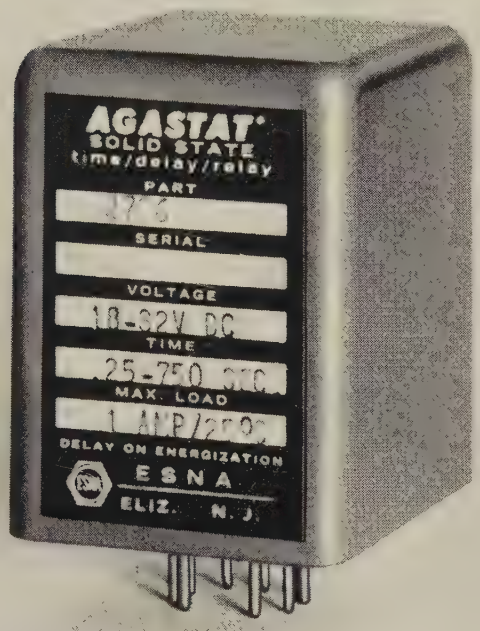
REALLY STACKED

In more ways than one. Stacked reels, a 3-stacked recording head, and an economy of size which would enable you to stack more than forty of these miniature tape recorders into a cubic foot of space. ■ Using less than 1 watt of power, the Precision Model PS-303M records an hour of voice frequency data on a single reel of tape. It operates quietly, weighs just a few ounces, incorporates an 8-transistor, 2-diode electronics circuit. ■ The space-saving reel design is the same used in PI instrumentation magnetic tape recorders. It is one of the many advanced features which enable all PI instruments to offer full-size performance in a fraction of the space. Write for our new short-form catalog for details.

PRECISION INSTRUMENT COMPANY
1011 Commercial Street • San Carlos • California
Phone LYtell 1-4441 • TWX: SCAR BEL 30
*Representatives in principal cities throughout the world*

*P.I. invites inquiries from senior engineers seeking a challenging future.*

# 1931...Birth of AGASTAT® reliability




# 1961...traditional quality in the new solid state **AGASTAT**

The AGASTAT time/delay/relay principle dates back to 1931, when the first night airmail flight from New York to Chicago was preparing for take-off. When runway lights failed due to old-style time delay relays, necessity fostered a new design. Thus, through a need for *reliability,* the electro-pneumatic AGASTAT was born—first in a distinguished series of time/delay/relays. **Solid state** AGASTATs meet today's needs for *reliability*. Countless hours of engineering, research and development have produced a static timing relay with the reliability essential for critical missile and computer use. Modular construction using selected semiconductor components permits flexibility and uniformity. Rigid quality control and component matching assure dependability.

**Solid state** AGASTAT time/delay/relays are supplied in six basic types for delay on pull-in or drop-out, with fixed or adjustable timing ranges from 0.01 sec. to 10 hours. Special circuitry protects against polarity reversal, provides immunity to voltage variations and transients. Operation—18-32 vdc; -55 to 125c; load capacity up to 5 amps. *Write* Dept. S2-211 for technical data or immediate engineering assistance on your special requirements.

**AGASTAT TIMING INSTRUMENTS**
ELASTIC STOP NUT CORPORATION OF AMERICA
ELIZABETH DIVISION • ELIZABETH, NEW JERSEY

*IN CANADA:* ESNA CANADA, LTD., 12 GOWER ST., TORONTO 16, ONTARIO, CANADA

No. 103 on Reader Service Card




**PLASMA GUN**—This 5-in. long, 3½ lb plasma gun has been developed for production line spraying, says **Avco Corp., Dept. S/A, 201 Lowell St., Wilmington, Mass.** The entire gun assembles with only four bolts securing the precision-machined parts. Avco says that it will spray coatings with a controlled thickness and density not previously obtainable, at twice the rate of comparable existing methods, and at savings up to 30 percent.

No. 277 on Reader Service Card

## DATA FILE

**FACILITIES**—Facilities, products, services, customers, and personnel are described in a booklet issued by **Nuclear Materials & Equipment Corp., Dept. S/A, Apollo, Penna.** This profusely illustrated booklet describes the company's four separate sites, including their plutonium facility, which is reported to be the world's first complete commercial facility for processing plutonium fuel bearing materials.

No. 278 on Reader Service Card

**INSULATING COATINGS**—High temperature coatings for protection of missile and rocket equipment are discussed in a brochure by **Swedlow, Inc., Dept. S/A, 6986 Bandini Blvd., Los Angeles 22, Calif.** Temperature limits, and a review of uses and application methods are shown for the materials.

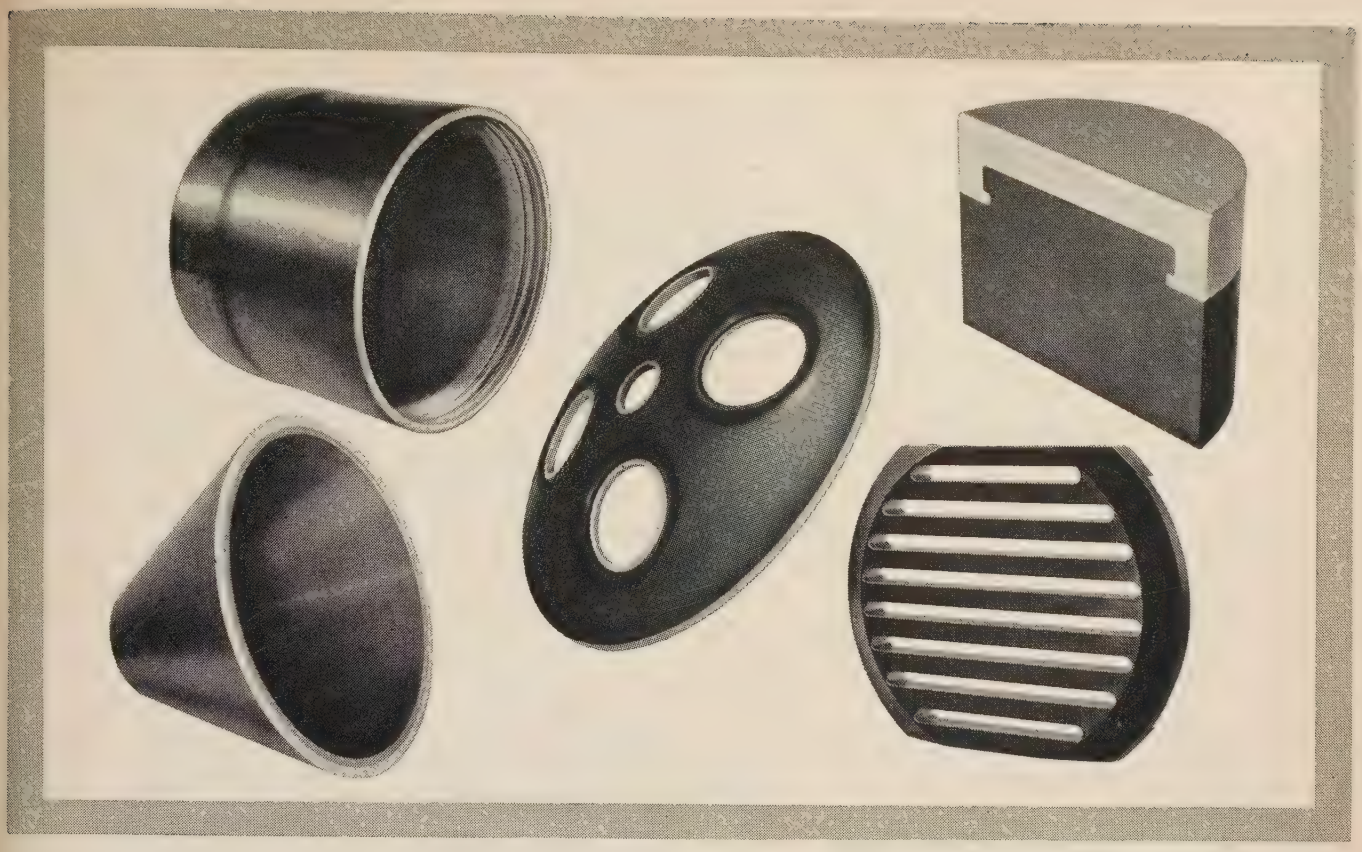
No. 279 on Reader Service Card

**BERYLLIUM BOLTS**—A readable review of the development of beryllium structural bolting is contained in a compact reference published by **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.** The booklet affords a review of the history of beryllium to date as a lightweight, structural material.

No. 280 on Reader Service Card

**WET BLASTING**—An informative bulletin, "40 Precision Finishing Operations Where You Can Cut Costs by Liquamatte Wet Blasting," has been issued by **Lord Chemical and Equipment Div., Wheelabrator Corp., Dept. S/A, 2068 So. Queen St., York, Pa.** The 24-page illustrated handbook shows how savings can be made in precision finishing costs through the use of wet blasting.

No. 281 on Reader Service Card



## Are you considering reinforced plastics for high-reliability parts and assemblies?

# TAYLORON® MATERIALS BELONG IN YOUR PLANNING

Tayloron materials are designed to excel in the ablation and thermal insulation requirements of missiles, rockets and spacecraft. They are available in sheet, plate, rod, tube, molding or preimpregnated form or as finished parts. And assemblies are not limited to the use of laminated plastics alone, but can include metals, rubbers and other materials in combination with Tayloron materials.

### HOW TAYLOR CAN HELP YOU

**Reinforced Plastics** We can supply a wide variety of laminate combinations for any test and evaluation program. Some are standard products, others are sophisticated variations of resin formulation, reinforcements, and fabrication methods. Years of experience in almost every thermosetting resin formulation and in all reinforcements, including asbestos, graphite cloth, and hi-silica content glass cloth, enables us to supply you with a material custom designed for your requirement. Properties of several outstanding Tayloron grades are shown on the following pages.

**Filament Winding** We can also design and produce prototypes or production quantities of filament-wound structures. Our Filament Winding Division will work with your basic idea—develop it into a successful structure of filament winding alone or filament winding in combination with Tayloron materials, metals and other materials.

### COME TO US WITH YOUR PROBLEMS

We are a completely integrated organization. We make our own resins, have extensive manufacturing, molding, forming, laminating, machining, and filament winding facilities. Two manufacturing plants—one in Norristown, Pa., the other in LaVerne, Calif.—assure you of good delivery and a dual source of supply wherever you may be located.

We maintain separate laboratories devoted to applied research in resin formulation, matrix composition, adhesive bonding systems, cellulose chemistry, and new material evaluations. Our Government-approved testing laboratories work closely with customers in developing reliable test methods.

Our facilities are at your disposal. If development work is needed, we will put a team on it at once. You can be assured that any facts you give us will be held in strictest confidence. Write the Advanced Materials Division outlining your specific problem. Taylor Fibre Co., Norristown 54, Pa.

**ADVANCED MATERIALS DIVISION**

**Taylor**

*REINFORCED PLASTICS / FILAMENT WINDING*

No. 104 on Reader Service Card

# TYPICAL PROPERTIES

## Advantages of Tayloron Reinforced Plastics in high-performance assemblies

**High strength-to-weight ratio.** In terms of weight, reinforced plastics are considerably stronger than most metals. Moreover, their strength characteristics may be directed where stresses demand. In filament or tape wound shapes, highest properties may be obtained.

**Good ablation qualities.** The capacity to keep on performing their basic function despite loss of some of their structure is an important characteristic of some reinforced plastics. Tayloron materials can be selected for various degrees of ablation and/or thermal insulation properties.

**Low heat transfer.** This, under extremely high temperatures, makes Tayloron ideal for protecting structural members in missiles.

**Excellent corrosion resistance.** High resistance to both atmospheric and chemical corrosion is a feature of reinforced plastics. This is particularly important in structural members where corrosion could generate failure locations.

**Comparative rigidity in cured condition.** This property prevents the reinforced plastic part from bulging or otherwise deforming when high pressures or other stresses are present. Thus original tolerances can be maintained under adverse operating conditions.

**Ease of fabrication.** A wide variety of shapes may be made to close dimensions by molding, laminating, or winding of filament or tape. Tayloron reinforced plastics are readily fabricated and machined.

**Taylor Fibre Co.**

NORRISTOWN, PA.

WEST COAST PLANT: LA VERNE, CALIF.

| Properties | | ASTM Test Method |
|---|---|---|
| Specific Gravity | | D-792 |
| Water Absorption (% by wt.) | | D-570 |
| Ultimate Flexural Strength (psi) | Lengthwise | D-790 |
| | Crosswise | |
| Ultimate Tensile Strength (psi) | Lengthwise | D-638 |
| | Crosswise | |
| Ultimate Tensile Modulus (psi) | Lengthwise | D-638 |
| | Crosswise | |
| Ultimate Compressive Strength (psi) | | D-69 |
| Ultimate Compressive Modulus (psi) | | D-695 |
| Shear Strength (psi) | Perpendicular | D-732 |
| | Parallel | |
| Izod Impact Strength (ft.-lb./in. of notch) | | D-256 |
| Rockwell Hardness | | D-785 |
| Bearing Strength (psi) | Lengthwise | D-953 |
| | Crosswise | |
| Thermal Conductivity Btu/in./ft.²/hr./°F | 150°F | C-177 |
| | 200°F | |
| | 250°F | |
| Specific Heat (Btu/lb./°F) | | C-351 |
| Diffusivity (250°F)(ft.²/hr.) | | |
| Coefficient of Linear Thermal Expansion (Range: —30° to 30°C) | Lengthwise (in./in./°C) | D-696 |
| | Crosswise (in./in./°C) | |

# OF TAYLORON MATERIALS

| Laminated Sheets | | | Molding Materials | | Laminated Sheet | Molding Material | Laminated Sheet | Molding Material | Laminated Sheet | Laminated Sheet |
|---|---|---|---|---|---|---|---|---|---|---|
| Tayloron 5000 | Tayloron 5033 | Tayloron 5031 | Tayloron 5033 | Tayloron 5031 | Tayloron PA-6 | Tayloron PA-6 | Tayloron PR | Tayloron PR | Tayloron PN | Tayloron PA |
| Combination of asbestos, nylon and phenolic resin | | | | | Asbestos and phenolic resin | | Silica and phenolic resin | | Nylon and phenolic resin | Asbestos and phenolic resin |
| 1.42 | 1.35 | 1.34 | 1.38 | 1.33 | 1.70 | 1.72 | 1.76 | 1.76 | 1.20 | 1.58 |
| 0.28 | 1.50 | 0.21 | 2.0 | 0.21 | .42 | .31 | 1.1 | 2.17 | 0.16 | 0.51 |
| 17,000 | 11,000 | 12,000 | 6,500 | 8,000 | 38,000 | 15,500 | 25,500 | 13,000 | 12,700 | 26,000 |
| 14,000 | 10,000 | 10,000 | | | 25,000 | | 25,000 | | 12,400 | 19,500 |
| 14,000 | 6,000 | 7,500 | 2,800 | 4,500 | 28,800 | 8,600 | 18,000 | 5,300 | 6,300 | 20,500 |
| 9,000 | 5,000 | 6,500 | | | 17,600 | | 16,000 | | 6,200 | 12,000 |
| $13.7 \times 10^5$ | $0.8 \times 10^6$ | $0.3 \times 10^6$ | $0.8 \times 10^6$ | $0.7 \times 10^6$ | $3.3 \times 10^6$ | $2.4 \times 10^6$ | $2.4 \times 10^6$ | $2.7 \times 10^6$ | $3.7 \times 10^5$ | $3.1 \times 10^6$ |
| $10.5 \times 10^5$ | — | — | | | $2.1 \times 10^6$ | | — | | — | $2.0 \times 10^6$ |
| 29,500 | 22,000 | 24,000 | 18,500 | 21,000 | 49,000 | 52,600 | 57,000 | 50,200 | 47,000 | 47,700 |
| $4.2 \times 10^5$ | $0.3 \times 10^6$ | $0.3 \times 10^6$ | $0.3 \times 10^6$ | — | $8.0 \times 10^5$ | $7.2 \times 10^5$ | $1.6 \times 10^6$ | $1.7 \times 10^6$ | $4.0 \times 10^5$ | $7.9 \times 10^5$ |
| 13,000 | 2,500 | 2,800 | 2,100 | 2,400 | 15,600 | 4,500 | 2,600 | 4,200 | 13,500 | 16,700 |
| — | — | 1,500 | | | 2,400 | | — | | — | — |
| 4.3 x 2.8 | 3.0 | 1.3 | 2.7 | 1.2 | 2.3 x 1.2 | 1.78 | 1.5 | 1.26 | 3.5 x 3.0 | 2.9 x 2.4 |
| M-98 | M-70 | M-90 | M-60 | M-85 | M-116 | M-113 | M-118 | M-121 | M-98 | M-114 |
| 26,000 | — | — | — | — | 29,000 | 11,500 | — | — | 11,000 | 28,000 |
| 20,000 | — | — | — | — | 23,000 | | — | — | 11,000 | 24,000 |
| .71 | .12 | .58 | 1.10 | .80 | .89 | .70 | — | 1.26 | .81 | .82 |
| .75 | 1.15 | .71 | 1.20 | 1.10 | .97 | 1.10 | — | 1.21 | .71 | .91 |
| .77 | 1.22 | .81 | 1.10 | 1.10 | .87 | 1.18 | — | 1.27 | .77 | .83 |
| .29 | .38 | .34 | .39 | .40 | .27 | .24 | — | .32 | .47 | .31 |
| 1.87 | 2.4 | 1.56 | 2.04 | 2.17 | 1.89 | 2.6 | — | 2.27 | 1.3 | 1.69 |
| $1.63 \times 10^{-5}$ | $2.80 \times 10^{-5}$ | $.358 \times 10^{-5}$ | $3.7 \times 10^{-5}$ | $3.5 \times 10^{-5}$ | $1.04 \times 10^{-5}$ | $1.18 \times 10^{-5}$ | — | $.80 \times 10^{-5}$ | $7.35 \times 10^{-5}$ | $.94 \times 10^{-5}$ |
| $1.96 \times 10^{-5}$ | — | — | | | $1.62 \times 10^{-5}$ | | — | | $6.44 \times 10^{-5}$ | $.71 \times 10^{-5}$ |

**NOTE:** Typical properties for laminated sheet and molded material based on ¼ in. thickness for all grades except Tayloron PR Laminated Sheet, which is based on ⅛ in. thickness.

No. 105 on Reader Service Card

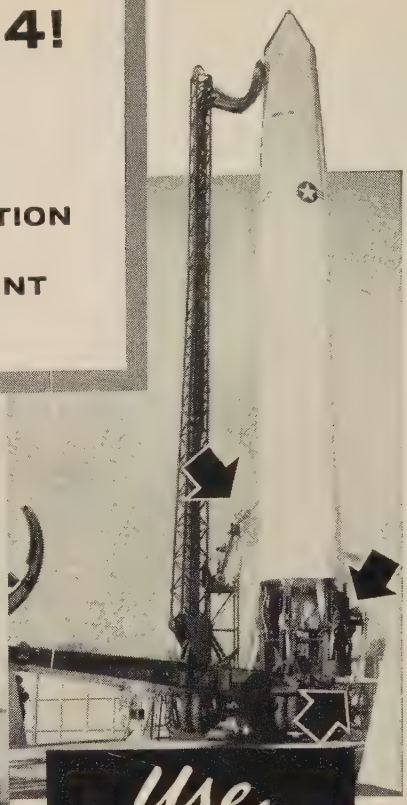
...when you need all 4!

1. SWIVEL MOTION
2. GIMBAL MOTION

*Provision for*
3. THERMAL CONTRACTION
*and Expansion in Fluid Lines*

4. ACCURATE ALIGNMENT
*of Piping*

Photos: Douglas-Air Force Thor IRBM.



Use BARCO Flexible BALL JOINTS

. . . in Missile Fueling Lines

Fluid lines for fueling missiles present complex problems. Barco Flexible Ball Joints solve these problems because ONLY BARCO can give you *gimbal motion* combined with *swivel motion* in hook-ups that allow for *thermal contraction* or *expansion* and still permit precise *positioning* of lines.

Barco joints are approved for missile service. They are used in lines conveying fluid fuels and oxidizers, including liquid oxygen, white fuming and red fuming nitric acid, and hydrogen peroxide. Your choice of sizes, styles, and types to meet current project requirements.

Barco engineers can give you assistance and time saving recommendations based on detailed experience with almost all significant projects since the beginning. Barco is a dependable source of supply, also offering possibilities for MINIMUM COST. *Check with Barco—IT PAYS!*

SEND FOR LITERATURE

CATALOG 233A—"Flexible Ball Joints for Handling Liquid Oxygen and Missile Fuels."

CATALOG 269B—"Plane and Self-Aligning Swivel Joints for Hydraulic Service."

BARCO

BARCO MANUFACTURING CO.
575M Hough Street
Barrington, Illinois

FLEXIBILITY FOR METAL PIPING
*Serving Industry Since 1908*




**STEEL**—Activities of **Pittsburgh-Des Moines Steel Co., Dept. S/A, Neville Island, Pittsburgh 25, Penna.,** are described in a 44-page brochure. Illustrations of a wide range of products in petroleum, chemicals, and other fields are included. Special sections are devoted to storage tanks and vessels and processing vessels for various materials.

No. 282 on Reader Service Card

**ELECTROLYTIC MACHINING**—Bulletin B-1 describing an electrolytic machining unit for cavity sinking or machining operations is available from **Anocut Engineering Co., Dept. S/A, 631 W. Washington Blvd., Chicago 6, Ill.** The unit's power supply produces to 10,000 amp, enabling a metal removal rate of 60 cubic inches per hour.

No. 283 on Reader Service Card

**REFLECTIVE COATINGS** — Radiant heat reflective coatings, their properties and uses with high temperature reinforced plastics, are described in a brochure by **Swedlow, Inc., Dept S/A, 6986 Bandini Blvd., Los Angeles 22, Calif.** Includes charts of high temperature characteristics of plastic laminates, uncoated and with gold or aluminum surfaces.

No. 284 on Reader Service Card

**PRODUCTS & SERVICES**—Bulletin 100-61 provides information on the products and services offered by **Swedlow, Inc., Dept. S/A, 6986 Bandini Blvd., Los Angeles 22, Calif.** Included is information on products such as reinforced plastics, aircraft transparencies, and high temperature coatings. Services information includes data on research and development, quality control, and engineering.

No. 285 on Reader Service Card

**PHENOLICS**—A six-page brochure describing properties and design considerations of phenolics has been published by **General Electric, Dept. S/A, 1 Plastic Ave., Pittsfield, Mass.** The brochure lists reference material for phenolics, as well as mechanical, electrical and chemical properties.

No. 286 on Reader Service Card

**LAMINATES**—A series of single-page data sheets describing phenolic glass and epoxy base laminates are available from **The Mica Corp., Dept. S/A, 4031 Elenda St., Culver City, Calif.** The sheets list properties, standard sizes, and applicable military specifications for the laminates.

No. 287 on Reader Service Card



No. 102 on Reader Service Card

*this is a man you should know . . . a Delavan fuel injector specialist*

# PERFORMANCE IS HIS RESPONSIBILITY

He is Richard O'Hara a Delavan Project Engineer who designs and develops after-burner fuel injectors and fuel nozzles. Ask him what kind of performance he wants from one of his fuel nozzle designs, he will tell you "The performance defined by customer specifications". And, this pretty well sums up the attitude of every member of Delavan's 40 man engineering department. Envelope dimensions, special tests, and reliability requirements are predetermined by you, the engine builder. Tell us these specifications and we'll design and manufacture your fuel nozzles . . . . on time and economically.

*get to know Delavan fuel injector specialists*

DELAVAN
*Manufacturing Company*
WEST DES MOINES, IOWA

No. 107 on Reader Service Card

# ENVIRONMENTAL

# BREATHING

## ...from Puritan

A leading authority in the development of oxygen breathing techniques in the field of medicine, Puritan was among the first to develop oxygen breathing systems for commercial air travel.

In applying its medical knowledge to the problems and objectives of aviation, Puritan recognized the necessity of providing ground level physiological environment during high altitude flight.

Puritan aerospace breathing systems are so designed and engineered. Your inquiry will receive prompt attention.

AEROSPACE DIVISION
Puritan EQUIPMENT, INC.
1703 McGee Street • Kansas City 8, Mo.
A subsidiary of PURITAN COMPRESSED GAS CORPORATION

**BREATHING LIFE INTO AIR AND SPACE TRAVEL**




**STEEL**—An ultra high strength steel with tensile strength values above 360,000 psi is described in a 20-page booklet. Available from **Vanadium-Alloys Steel Co., Dept. S/A, Latrobe, Penna.**, this Vascojet M-A matrix steel features a yield strength of 290,000 psi. In addition to discussing the various properties of the steel, the brochure includes tables and performance curves.

No. 288 on Reader Service Card

**ADHESIVES**—A two-page data sheet, entitled "Chemfacts," offering information on bonding uncured elastomers to metal is available from **Hughson Chemical Co., Dept. S/A, Erie, Pa.** The data sheet discusses bonding theory in detail and lists other bulletins available.

No. 289 on Reader Service Card

**FACILITY**—An eight-page brochure describing a facility for engineering service concerning parts made of silicone molding compounds is offered by **Dow Corning Corp., Dept. S/A, Midland, Mich.** The brochure discusses engineering, testing and molding capabilities.

No. 290 on Reader Service Card

**MULLITE TUBES**—In a 4-page pamphlet, **Morganite, Inc., Dept. S/A, 3302 48th Ave., Long Island City 1, N. Y.,** discusses their impervious mullite pyrometer protection tubes and combustion and furnace tubes. In addition to giving a description and list of properties, the pamphlet lists catalog numbers of various size tubes, including one end closed type, both ends open type, and single reduced end type.

No. 291 on Reader Service Card

**BRASS**—A handbook discussing applications of brass has been published by **Riverside Alloy Metal Div., H. K. Porter Co., Inc., Dept. S/A, Riverside, N.J.** The booklet contains data on composition, specifications, properties, and other technical information concerning brass wire, rod and strip.

No. 292 on Reader Service Card

**MACHINERY**—An Engineering Data Catalog describing a "building block" concept of machinery fabrication or conversion of existing machinery is available from **The Standard Electrical Tool Co., Dept. S/A, 3001 River Rd., Cincinnati 4, Ohio.** Typical units are discussed, as well as accessories such as feed and cycling equipment.

No. 293 on Reader Service Card



No. 106 on Reader Service Card

No. 164 on Reader Service Card

## Reliable Rodney Says: THERE'S NOTHING NEW UNDER THE SUN

Honeycomb is old stuff to the bee. He's been using it from time immemorial. It took man's ingenuity to recognize it as one of the strongest yet lightest methods of fabricated construction. The solution is not that simple, though, when applied to making honeycomb for the aircraft and missile industry.

Besides the problems of strength, weight, heat resistance, ratio of urface area to volume, there is the critical requirement of maintain- ng uniform thickness of the stainless steel and high temperature alloy oils used to make this sandwich structure.

This area of precision rolling is where Rodney leads the industry. pace age alloy foils are being rolled to super thin tolerances in the idest strips available anywhere. We can do this at Rodney because e pioneered in the development and use of special equipment and chniques. Our *two* Sendzimir mills, equipped with continuous, on-contact thickness gauges, roll accurate foils in widths up to 5 inches. Our continuous bright annealing lines process foils in the idest strips available anywhere. In addition, precision slitters, acid eaning lines, and various types of visual and instrumented inspec- on lines give us a leading position in this industry.

To further refine our specialization in producing the thinnest and widest strip available, we maintain a modern laboratory for quality control, research, and development. These laboratory facilities and our technical experience in this field are available for the solution of your special problems.

An illustrated brochure is available on request.

STAINLESS STEELS • HIGH TEMPERATURE ALLOYS • EXOTIC METALS (Refractory)

RODNEY ROLLED IS QUALITY CONTROLLED

**RODNEY METALS, INC.** MILL: NEW BEDFORD, MASS.

West Coast Office and Warehouse: 5462 East Jillson St., Los Angeles 22, Cal.

**SILICONE RUBBER**—An eight-page, illustrated technical bulletin on silicone rubber for wire and cable insulation is available from the **Silicone Products Dept., General Electric, Dept. S/A, Waterford, New York.** In addition to tables showing typical properties of silicone rubber, the publication is illustrated with wire and cable constructions and applications.

No. 294 on Reader Service Card

**WELDING**—Issue No. 613 of "Weld-It" discusses the use of two ENC-19-100 resistance welds to make two simultaneous T-welds. Issued by **The Taylor-Winfield Corp., Dept. S/A, Warren, Ohio,** this issue also covers T-welds in tubular steel furniture.

No. 295 on Reader Service Card

**EXTRUDED TUBING**—Product Data Sheet 1 describing Teflon tubing for heat and corrosion resistant applications has been issued by **Timely Technical Products, Inc., Dept. S/A, 100 Pine St., Verona, N.J.** The tubing is extruded to individual specification and tolerance requirements.

No. 296 on Reader Service Card

**STEEL**—Properties of Vasco Jet 1000, an alloy steel for ultra high strength structural requirements, are covered in a comprehensive 24-page booklet issued by **Vanadium-Alloys Steel Co., Dept. S/A, Latrobe, Penna.** Various property curves and tables are given, together with the narrative describing these properties. Applications and typical products are also given.

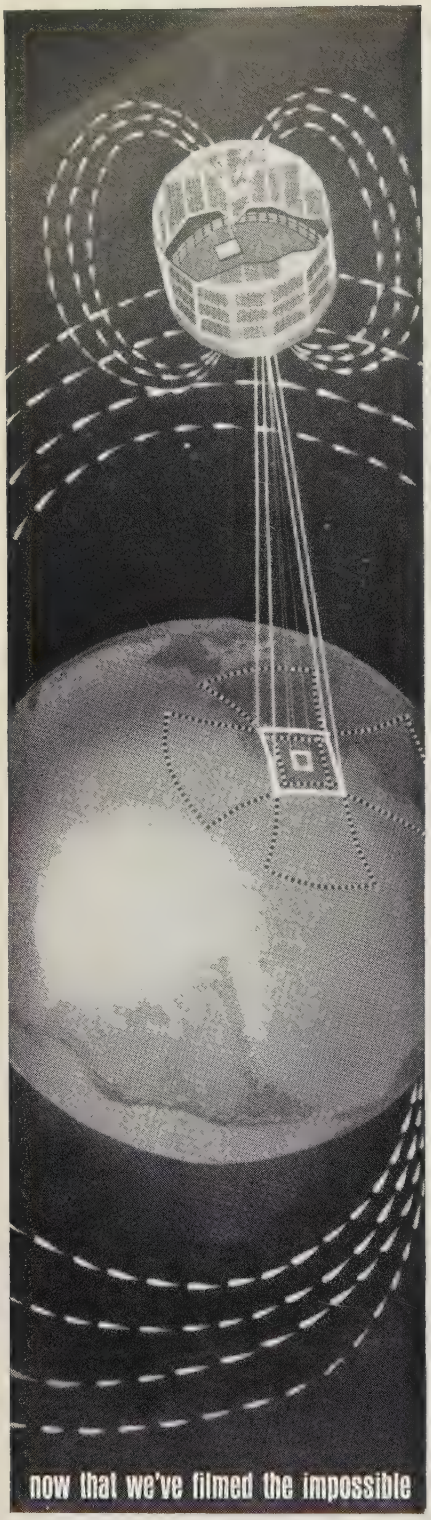
No. 297 on Reader Service Card

**FASTENERS** — An eight-page booklet on Sel-Lok Spring Pins is offered by **Industrial Fastener Div., Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.** It describes and illustrates typical applications, and lists specifications.

No. 298 on Reader Service Card

**PLASTICS**—Properties of eight plastics are compared in a 4-page brochure prepared by **Cadillac Plastic & Chemical Co., Dept. S/A, 15111 Second Ave., Detroit 3, Mich.** Using graphs, the following properties are covered: thermal conductivity, specific gravity, temperature, impact strength, ultimate tensile strength, modulus of elasticity, flexular modulus, thermal expansion, and heat distortion temperatures.

No. 299 on Reader Service Card

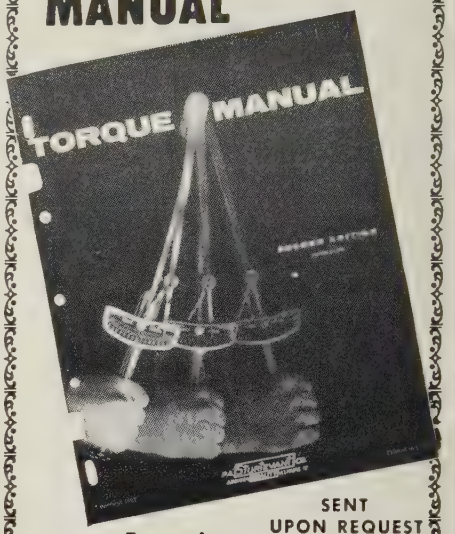

**what can we do for you?**

We had the answer for TIROS...for NIMBUS. We've had the answer to movie camera, still camera, X-ray camera and aerial camera problems. We've had the answer to problems of **high** volume-**low** unit costs; we've had the answer to problems where few-of-a-kind are involved. If your company is facing an optical design problem, Elgeet's engineering and design section welcomes the challenge to create the breakthrough that you require.

Write: Elgeet Optical Company, 838 Smith St., Rochester, N.Y. Elgeet EL-63

No. 108 on Reader Service Card

**"TORQUE WRENCH" MANUAL**

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**Formulas**
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ADDISON QUALITY ILLINOIS

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For your address of distinction, near business activity, smart shops and entertainment.

Luxurious yet informal...spectacular figure-8 pool...fine food at the Cafe Carlton Coffee Shop ...ample parking. It all adds up to the ultimate in convenience and comfort for you!

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# OME and LOSURE ORGINGS

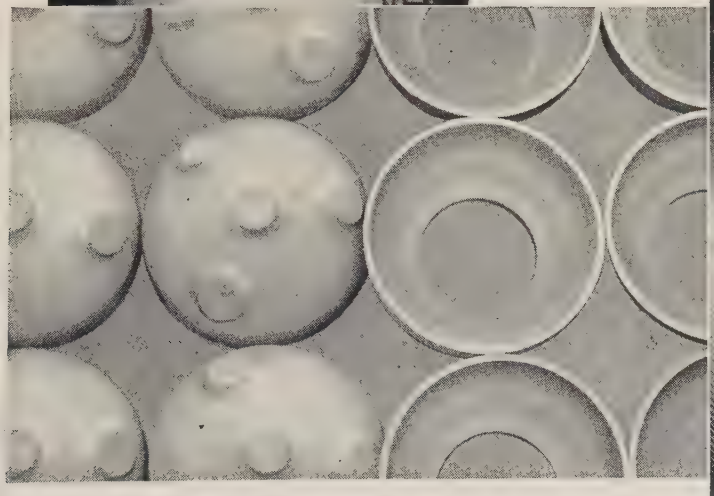
ed solid-propellant sile capabilities

FORGED

## OUT OF HIGH-STRENGTH STEELS AND TITANIUM ALLOYS

Dome and closure components, forged and machined by Wyman-Gordon in both low-alloy, high-strength steels and all-beta Titanium—have contributed measurably to our present status in solid-fuel missile development. Research is continuing for the purpose of adapting new materials to these applications. Wyman-Gordon engineer-metallurgists are available to counsel on all phases of forging such critical-service parts. Their assistance can help extend ultimate-strength limits of your space designs.

EST. 1883



# WYMAN-GORDON

## FORGINGS

*of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials*

HARVEY ILLINOIS WORCESTER MASSACHUSETTS DETROIT MICHIGAN

GRAFTON MASSACHUSETTS LOS ANGELES CALIFORNIA PALO ALTO CALIFORNIA FORT WORTH TEXAS

# DESIGN DEVELOPMENTS

*For more details on the equipment, processes, and facilities described in this section,*

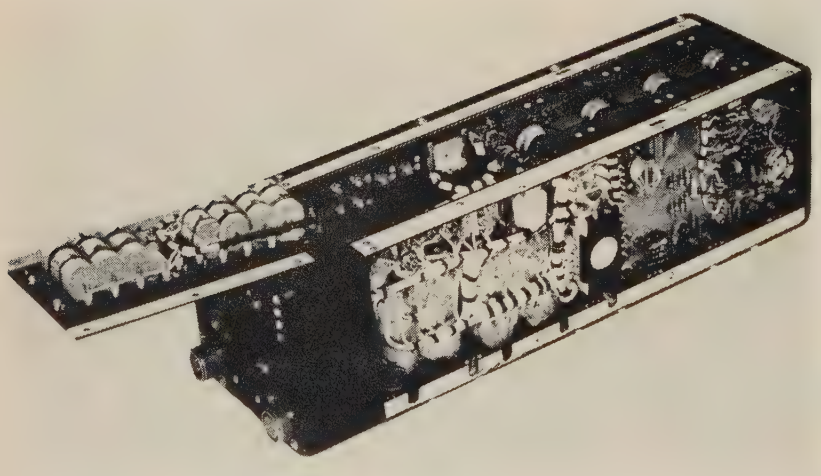
## ELECTRIC SYSTEM PROTECTED AGAINST SHORTS FROM $MoO_3$ VAPOR

During simulated space flights of the Dyna-Soar vehicle, it was noted that, at 1500 deg F, the electric systems were short-circuiting. Below 500 deg F, the phenomenom disappeared. Engineers at The Boeing Co., Seattle 24, Wash., found that the cause of the trouble was molybdenum trioxide a vapor formed at high temperatures.

The tendency of molybdenum to oxidize at high temperatures is normally overcome by coating it with a protective material. Tiny holes and hairline cracks that occasionally develop in this coating are usually not severe enough to affect the structure. However, they are often big enough to expose minute areas of molybdenum and permit the formation of molybdenum trioxide, which penetrates electric wiring. Being highly conductive at 1500 deg F, this vapor short-circuits electric signals. Below 500 deg F, the vapor crystalized and formed tiny whiskers that acted like insulation, thus correcting the trouble.

To overcome its problem, Boeing now plans to protect the Dyna-Soar's electric wiring by encasing it in solid metal sheathing. This sheathing will be only slightly larger than the wires themselves. A mile of sheathed wire will weigh about 40 lb.

## Static Inverter Based on Successful F-105 Design



A 600-va static inverter providing enough power for prime power applications yet versatile enough for use on most aircraft and ground support programs, has been announced by Electrosolids Corp., 13745 Saticoy St., Panorama City, Calif. The new unit is a modification of the 500-va W-1377-1 inverter, which has proven extremely reliable on the F-105. Electrosolids reports that this new design meets all applicable Mil specs.

Designated the W-1651, this 27-lb unit meets the following specifications: 25-31 V DC input voltage, 32 amp input current at 25 V DC, 115/200 V AC output voltage, 600 va output power, sinusoidal waveshape, 400 cps output frequency over ambient temperature and input voltage range, less than five per cent RMS distortion, 0.8 lagging power factor, 75 per cent minimum efficiency at full load, 60 deg C blast air temperature, four ppm blast air volume, up to 100,000 ft altitude; 20 g acceleration.

An internal 23,000-rpm, three-phase, 400-cps fan provides cooling. Since the fan is connected as a balanced load to the output, it does not affect the input or the operation of the inverter. **50**

## Engine Temperature Indicator Designed for Maximum Resolution

To maintain the delicate balance between maximum jet engine thrust and damage to turbine buckets due to overheating, Consolidated Airborne Systems, Inc., 900 Third Ave., New Hyde Park, N.Y., has developed its Con-Temp DST-16 temperature indicator. The indicator provides stable, accurate indication of operating temperature as measured by a standard chromel-alumel thermocouple probe. The complete system is contained in a two-inch diameter, six-inch-long, panel-mounted case. It consists of a three-stage transistorized amplifier, a reference voltage source, a reference junction compensator, a rebalance potentiometer, a motor and gear train, an da power failure warning indicator. The thermometer is a self-balancing potentiometer type in which the thermocouple probe, the rebalance potentiometer, and the reference junction compensator forms a bridge network. A low-inertia servo motor drives the rebalance potentiometer wiper to null the bridge. The drive mechan-

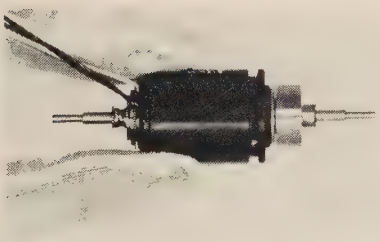
# Propulsion and Accessory Equipment

*write in item numbers on Reader Service card*

ism operates the pointer, which accurately interprets the mechanical setting of the rebalance potentiometer in terms of temperature. By controlling the winding characteristics of the potentiometer, any range of temperature scale expansion or compression can be obtained to maximize the resolution in the vicinity of the temperature of interest.

The circuit is designed for a high degree of isolation from the effects of voltage supply variation and environmental variations. A failure warning indicator that operates in the event of internal as well as external power supply failure is included and the unit is integrally illuminated in accordance with military specifications. Corollary functions like time-temperature recording, telemetering output, synchro output for remote indication, etc., may be added or removed as required. **52**

## Miniature Drive Motor Runs Smoothly



Designed for light-duty applications—such as driving potentiometers, slip rings and synchros—this miniature drive motor is being produced in sizes 10, 11, and 12. It is in use in timing devices, telemetering systems, and oscillating ball bearing drives for gyro gimbals. Developed by the Barden Corp., Danbury, Conn., the unit is essentially a drive motor with a miniature gearless speed reducer.

While the drive is not intended as a substitute for conventional gear head motors (its torque output is too limited), it has the advantage of smooth operation. It is said to be capable of withstanding vibration of 20 g from 10 to 2500 cps.

Input-output speed ratios range from 25 to 5000. Electric characteristics can be specified by the user. **51**

**SERVO AMPLIFIER**—A 3.5-W-servo amplifier for missile, space vehicle, aircarft and airborne instrument applications has been developed by **The Siegler Corp., Magnetic Amplifiers Div., Dept. S/A, 632 Tinton Ave., Bronx 55, N.Y.** The unit is suited for use in analog computers, automatic controls, and remote indicating and positioning systems. Designed to operate with direct input from a 115 volt a-c line, the amplifier is 80 per cent efficient, eliminating the need for a heat sink when functioning in an ambient temperature range from —55 to +125 deg C.

No. 300 on Reader Service Card

**POWER CONVERTERS**—A line of power converters featuring a significant improvement in conversion efficiency are suited for applications where the power source is a thermoelectric generator, fuel cell, or low voltage battery. The efficiency of the new unit is greater than 75 per cent, says **The Hoover Co., Dept. S/A, P. O. Box 18, Baltimore 3, Md.** A wide range of input and output parameters is available. Complete solid-state construction eliminates maintenance considerations. Converters with an input as low as 0.1 volt are said to be practical.

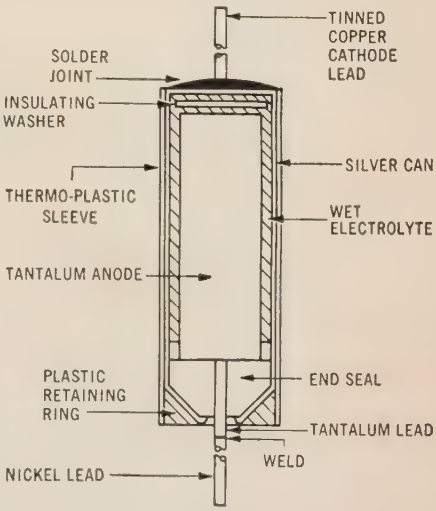
No. 301 on Reader Service Card


NEW

STRAIGHT WALL TANTALUM CAPACITOR CAN'T LEAK

**Meets MIL C 3965-B, Style CL-64, CL-65.**

A new space-saving approach to the design of wet tantalum capacitors ends mounting problems encountered with flanged types and yet will not leak.




ITT's compact, sintered slug tantalum capacitor features a wedge-shaped seal held under compression by an epoxy retainer ring formulated for thermal characteristics inverse to those of silver. Ordinary, straight-wall capacitors leak along the lead when elastomer compression is reduced as the silver can expands. Not so with the new ITT design!

This new, compact capacitor conforms to specifications MIL C 3965-B, Style CL-64, CL-65 and provides both the compactness and rugged reliability required in missile, airborne and mobile equipment. For details, write today requesting Bulletin No. 610.

ITT

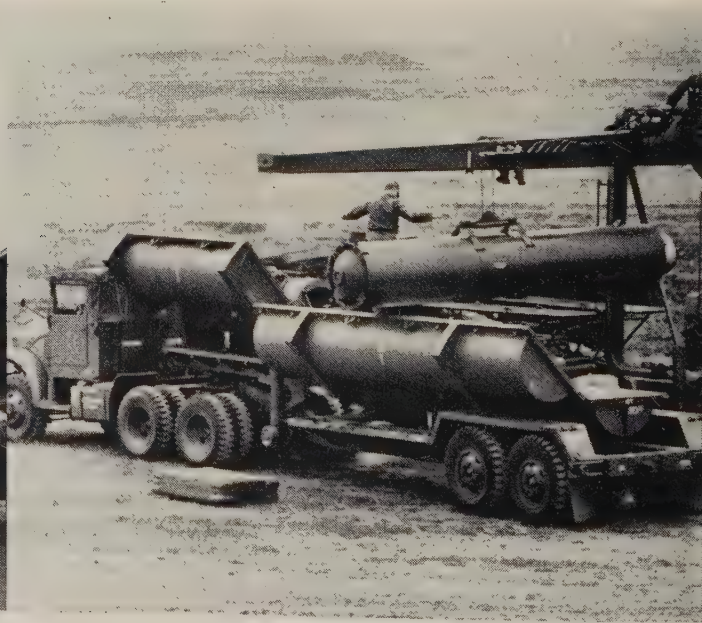
CAPACITOR DEPARTMENT
COMPONENTS DIVISION
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION, PALO ALTO, CALIFORNIA

No. 112 on Reader Service Card

**Half-mule, half-bird** The U.S. Army's Sergeant, now in production, is artillery and it can traverse terrain where caissons used to go rolling along. And for long fast hops, the Sergeant can readily be airlifted. The prime contractor, Sperr Utah, wisely selected new, light gages of USS "T-1" Constructional Alloy Stee with 100,000 psi yield strength for the ground support special purpose equipment USS "T-1" Constructional Alloy Steel is three times stronger than structura carbon steel, thus fabricated components can be made thinner and lighter wit no sacrifice in strength. The entire launcher is air-transportable because i weighs only 16,000 pounds—7,000 pounds less than if built with structura

Steel "Keeps America's strength high."

Wide use of USS "T-1" Steel makes the transporter-erector-launcher 7,000 pounds lighter and completely air-transportable.



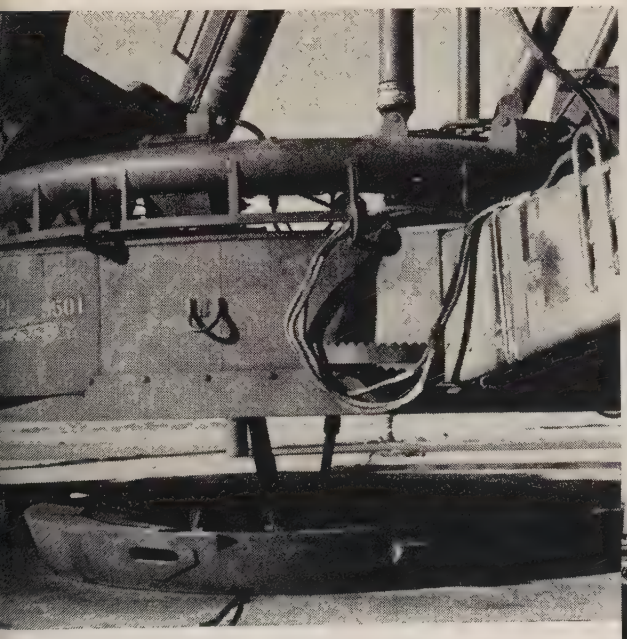
Frame components of special purpose container transport trailers are "T-1" Steel; launcher boom is also "T-1" Steel, for maximum strength and minimum weight.

All major structural components were designed at an allowable working stress of 66,700 psi.

carbon steel. When your missile support system goes on the drawing board, you can obtain applications and development assistance by consulting the one producer of all basic materials for support hardware and facilities. Whether it's carbon steel or special constructional alloy steels, electrical cable or wire rope...consult

**USS United States Steel**

*USS and "T-1" are registered trademarks*



½" diameter welded USS "T-1" Steel tubing forms the rus ring of the launching superstructure.

USS "T-1" Steel outrigger legs stabilize the unit in firing position. Also made of "T-1" Steel are the U-frame, extension arms, top and rear tension members and back beam.

SHOWN ACTUAL SIZE

# SIZE 5 COMPONENTS

## FOR SERVO SYSTEM MINIATURIZATION

A complete family of Size 5 components for every servo system function is now available from Kearfott. Stainless steel housings, shafts and bearings protect the units against environmental extremes and contribute to stability under shock, vibration, and temperature fluctuations. • Standard 26-v, 400-cps excitation. • Operating temperature range −55° to +125°C.

### CHARACTERISTICS

**SYNCHROS**

| | VOLTAGE (400 cps) | T.R. | NULL (mv) | ERROR (min) |
|---|---|---|---|---|
| Transmitter | | | | |
| CJO 0565 100 | 26 | .454 | 34 | 10 |
| Control Transformer | | | | |
| Low Z-CJO 0555 100 | 11.8 | 1.765 | 34 | 10 |
| High Z-CJO 0552 900 | 11.8 | 1.765 | 34 | 10 |
| Differential | | | | |
| CJO 0595 100 | 11.8 | 1.154 | 34 | 10 |
| Resolver | | | | |
| Low Z-CJO 0585 100 | 26 | 1.0 | 34 | 10 |
| High Z-CJO 0589 100 | 26 | 1.0 | 34 | 10 |

**SERVO MOTORS**

| | J126-06 | J126-02 |
|---|---|---|
| No-Load Speed | 9800 rpm | 9800 rpm |
| Stall Torque | 0.10 in. oz | 0.10 in. oz |
| Rotor Moment of Inertia | 0.175 gm cm² | 0.175 gm cm² |
| Voltage $\phi 1/\phi 2$ (400 cps) | 26/36-CT | 26/26 |
| Power Input/Phase | 1.7 w | 1.7 w |

**SYNCHRONOUS MOTOR**

| | CJO 0172 200 |
|---|---|
| Pull-In Torque | 0.06 in. oz |
| Pull-Out Torque | 0.10 in. oz |
| Pull-Out Power | 4 w |

**MOTOR GENERATORS**

| MOTOR | CJ40812001 | CJO0812650 | CJO0813200 |
|---|---|---|---|
| Voltage $\phi 1/\phi 2$ (400 cps) | 26/36-CT | 26/36-CT | 26/26 |
| Power /$\phi$ | 1.5 w | 1.5 w | 1.5 w |
| No-Load Speed | 8000 rpm | 8000 rpm | 8000 rpm |
| Stall Torque | 0.10 in. oz | 0.10 in. oz | 0.10 in. oz |
| **GENERATOR** | | | |
| Voltage (400 cps) | 26 v | 26 v | 26 v |
| Volts/1000 RPM | 0.1 v | 0.1 v | 0.5 v |
| Null | 1.3 mv | 10 mv | 6.7 mv |

Size 5 gearheads range in reduction ratios from 20:1 to 1019:1 for servomotors and motor tachometers above. In addition to Size 5 clutches, brakes, and brake-clutches, Size 6 are available.

*Write for complete data*

KEARFOTT DIVISION
GENERAL PRECISION, INC.

*Little Falls, New Jersey*



**MONOPLANER SWITCH** — The availability of "Uniplane" switch kits which allow assembly of over 1000 multicircuit combinations is announced by **The Ucinite Co., Dept. S/A, 459 Watertown St., Newtonville, Mass.** All components and interconnections are made on a single flat surface. Reliability in the switch is increased by the reduction of the number of solder joints. The units are both shorting and non-shorting types. Mounting of components and elements on a flat surface is said to increase accessibility.

No. 302 on Reader Service Card

**ROLLER BEARING**—A recirculating roller bearing has a coefficient of friction of 0.00025 under 2000 lb load and 0.25 in. per min linear motion. With this load and speed, the bearing has ⅛ the coefficient of friction compared to other bearings of this type, according to **The Kaydon Engineering Corp., Dept. S/A, Muskegon, Mich.** Precision matched sets may be obtained with a total height variation within 10 $\mu$inch.

No. 303 on Reader Service Card

**POLYESTER BELTS**—Oriented polyester belts for power transmission and conveying are available in endless belts with smooth-running flexible splices. **International Ultrasonics, Inc., Dept. S/A, 331 Centennial Ave., Cranford, N. J.,** offers these belts, tapes, and loops spliced without heat or adhesives. The belts are supplied in any length with widths from ¼ in. or less to 60 in., and thickness from one to 10 mils.

No. 304 on Reader Service Card

**BLADDERS**— Teflon fuel expulsion bladders and diaphragms are said to offer complete impermeability to chemical attack from exotic fuels and oxidizers. **Dielectric Corp., Dept. S/A, Allen Blvd. & Gran Ave., Farmingdale, N. Y.,** reports that these devices can be fabricated to very close tolerances within a range of wall thicknesses from 0.004 to 0.020 in.

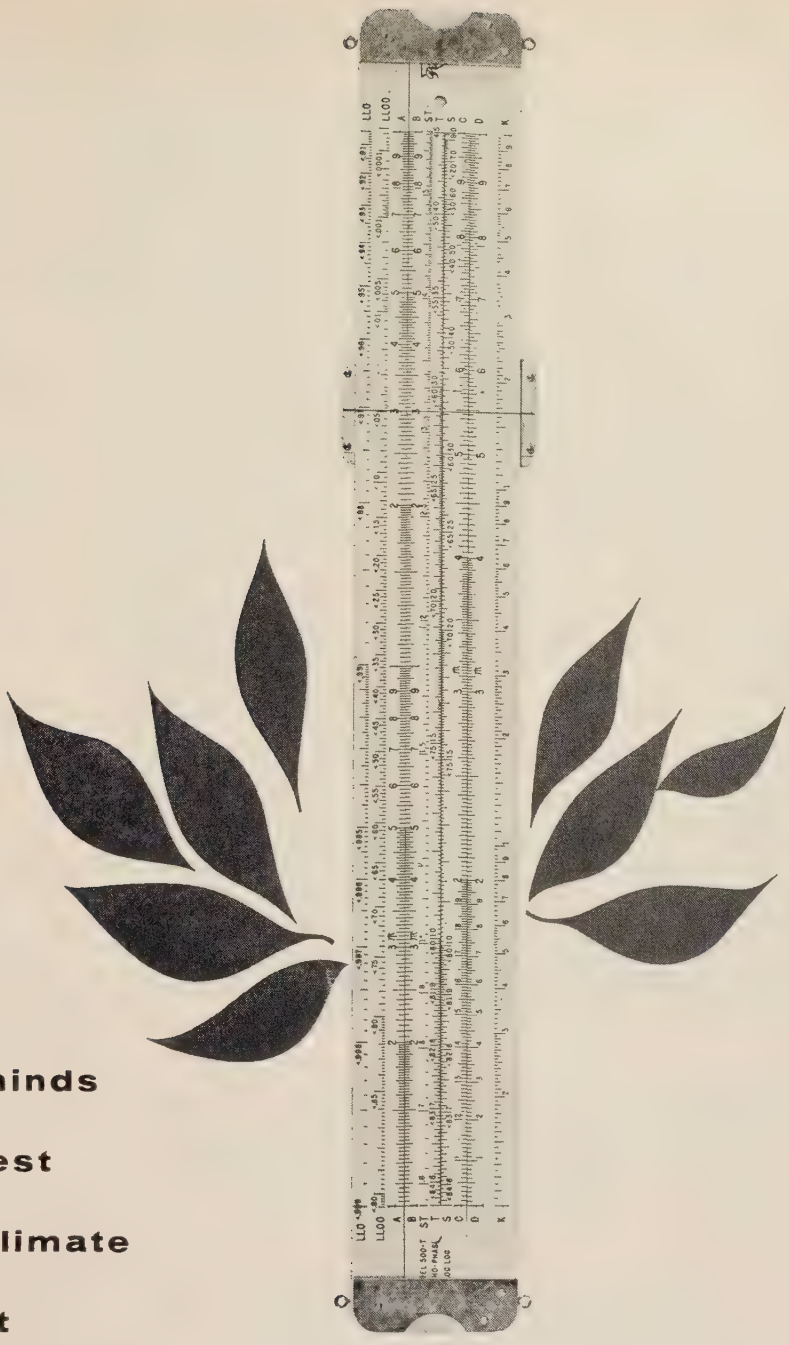
No. 305 on Reader Service Card

**LIQUID LEVEL CONTROL** — The Cryolevel is a liquid level control instrument specifically designed for cryogenic applications. The unit is capable of maintaining accurate levels in liquids as low as 4 deg K, says **Cryotronics, Inc., Dept. S/A, Mountainside, N. J.** The Cryolevel uses an adjustable dual element probe to maintain a liquid level within a preset range from ±¼ to ±6 inches.

No. 306 on Reader Service Card



No. 113 on Reader Service Card



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**thrive best**

**where the climate**

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Lockheed-California Company proves this every day. For nowhere do Scientists and Engineers find a more creative, more stimulating, more academic climate.

In this environment Scientists and Engineers are encouraged to try the untried; to express new ideas; to experiment and explore. And in so doing, win recognition and reward.

Small wonder Lockheed's future in *Spacecraft and Aircraft* is brighter than ever before!

**Scientists and Engineers** of initiative and talent will find it worthwhile to examine immediate openings in: Aerodynamics; thermodynamics; dynamics; electronic research, servosystems; electronic systems; physics (theoretical, infrared, plasma, high energy, solid state, optics); electrical and electronic designers; structural design (wing, empennage, fuselage).

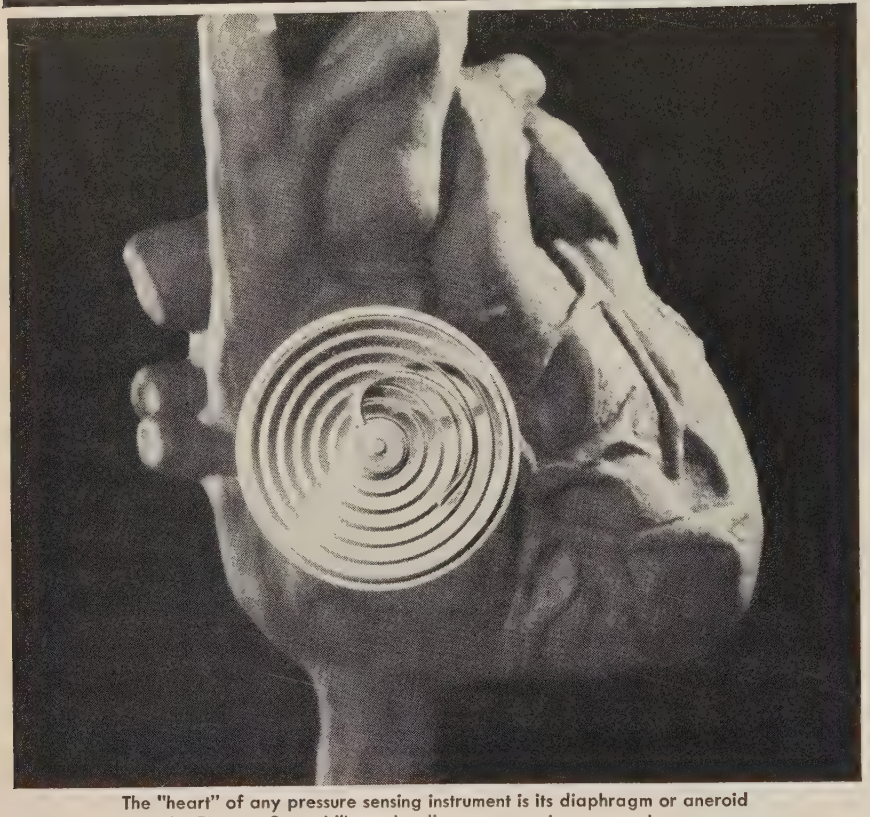
Write today to Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1911, 2401 N. Hollywood Way, Burbank, California. All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin. U.S. citizenship or existing Department of Defense industrial security clearance required.

**LOCKHEED·CALIFORNIA CO.**

*A DIVISION OF LOCKHEED AIRCRAFT CORPORATION*

KNOW-HOW IN ACTION AT BENDIX PIONEER-CENTRAL

**PRESSURE SENSING**



The "heart" of any pressure sensing instrument is its diaphragm or aneroid capsule. Pioneer-Central "know-how" assures maximum capsule accuracy.

# EXTRA QUALITY IN DIAPHRAGMS AND ANEROIDS FOR PRECISION INSTRUMENTS

Special machinery has been designed and built at Pioneer-Central for manufacturing and testing diaphragm and aneroid capsules. This machinery—along with our highly trained personnel—makes possible the manufacture of capsules so *sensitive* they are calibrated with hairspring adjustments and so *rugged* they can withstand overpressures of fifteen times their working pressures.

Hysteresis problems have also been effectively eliminated by our ability to measure hysteresis characteristics to within .00002 inch.

Our pressure sensing instruments reflect forty-two years' experience. They include: Altimeters; Rate of Climb, Airspeed, and Mach Number Indicators; and Control Devices for use in such applications as Oxygen Regulators.

Other areas of outstanding Pioneer-Central capabilities include Inertia Sensing, Cryogenics, Life Support, Propellant Control, and Acoustical Engineering.

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**Pioneer-Central Division**

THE Bendix CORPORATION

No. 114 on Reader Service Card



**ROD ENDS** – Large size rod ends, control rod assemblies, and high angle rod ends with studs, are applied in linkage systems where misalignment must be accommodated. Construction features of the units permit sustained rotational operation, says **Split Ballbearing, Div. of MPB, Inc., Dept. S/A, Lebanon, N. H.** Bearings feature a precision ground, through-hardened steel race around an oil-impregnated sintered metal ball.

No. 307 on Reader Service Card

**VALVE**–This high-speed valve is for use in aircraft arresting devices. It is a large capacity, high pressure valve which can be opened in 15 msec to produce an explosive air blast of considerable force, says **Research, Inc., Dept. S/A, Box 6164, Minneapolis 24, Minn.** Applications are in rapid pressurization of pressure vessels, rapid pressure release, or in high-energy metal forming. Maximum operating pressure is 1500 psi.

No. 308 on Reader Service Card

**SPRING SHOCK** –This Model 151-284 double-acting, time delay, Spring Shock uses liquid compressibility, according to the manufacturer, **Taylor Devices, Inc., Dept. S/A, 188 Main St., No. Tonawanda, N.Y.** After absorbing shock force, the liquid spring provides a 4000 lb output over a 1-in. stroke. Shock resistance is 13,000 lb on a flat topped energy curve, at any impact velocity below a specified 90 in./sec.

No. 309 on Reader Service Card

**HYDRAULIC MOTORS**–High efficiency and control accuracy are featured in this line of variable displacement hydraulic motors available from **Vickers, Inc., Dept. S/A, Detroit 32, Mich.** These axial piston units are a lightweight source of power for a-c generators, fuel boost pumps, turbine starters, and compressors. Typical units are designed for ±1.0 percent steady state regulation, and are fitted with centrifugal type governors.

No. 310 on Reader Service Card

**COUNTER** – A new four-digit indicator measures only ½ in. square by 1 9/16 in. long, and operates from a 28-volt d-c source Designed by **A. W. Haydon Co., Dept. S/A, Waterbury, Conn.**, the unit weighs 0.75 oz and employs a four-digit drum counter having a range of 9999 events or starts. White numerals on a lusterless black background offer excellent readability. Applications include airborne radar, or as a rounds counter for airborne guns.

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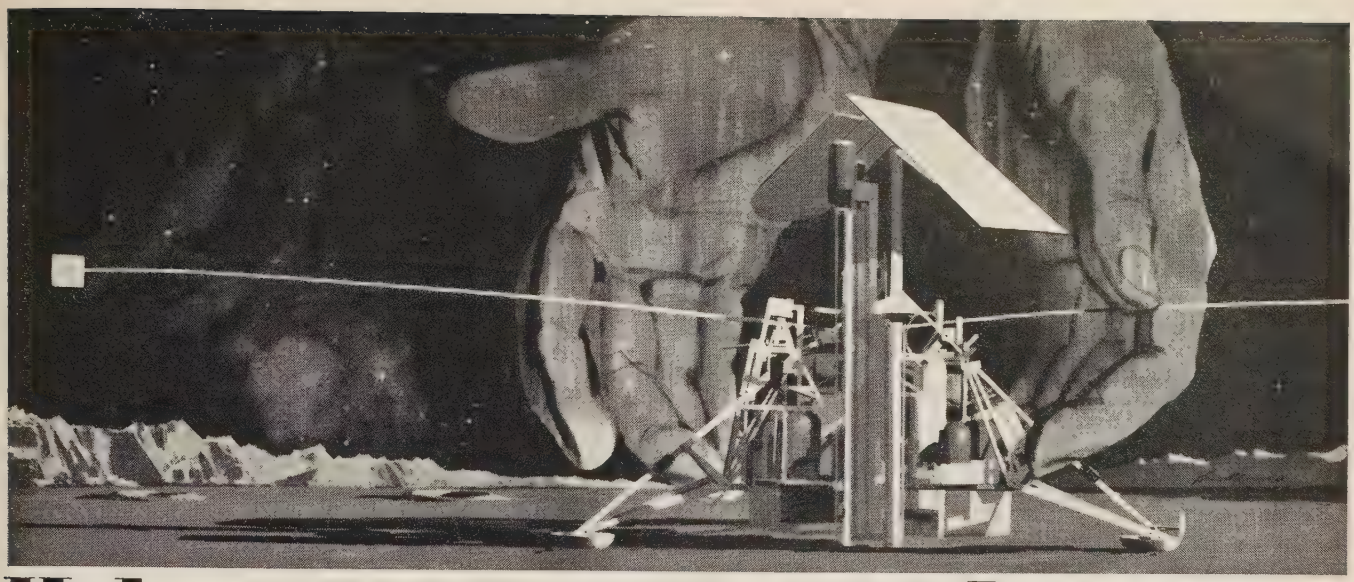


# Help put surveyor on the moon

Sometime in 1963, the first of several Hughes-built SURVEYOR vehicles will be put into lunar-impact trajectory for a soft landing on the moon. Surveyor instruments will perform a variety of scientific tasks: drills will pierce and analyze the moon's surface; high quality television pictures will be transmitted to earth; other instruments will measure the moon's magnetic and radiation characteristics. ■ To accomplish this step into space, Project Surveyor requires the talents of imaginative junior and senior engineers and physicists to augment its outstanding staff. Experience is preferred, but not required. ■ Unprecedented opportunities now exist on Surveyor and other projects, such as: ARPAT (terminal anti-ballistic missile defense system), BAMBI (anti-ballistic missile feasibility study), SYNCOM (synchronous communications satellites), POLARIS guidance and others.

**CONTROL ENGINEERS**—with experience in such areas as hydraulics, airborne computers, control circuitry, microwave antennas and other areas related to controls for the following areas of work: Missiles & Space Vehicles (attitude control—roll, pitch and yaw); Satellites (orbital control); Radar Tracking (hydraulic control of vertical and azimuth); Control Circuitry (preliminary and breadboard design); Control Systems (adaptive space control systems); Control Techniques (advanced non-linear); Equalization Networks (transistorized); Control Servomechanisms (design and debugging of controls, servomechanisms, sensors and other components); Missile Defense Systems (airborne computers and analog simulations of anti-ballistic missile defense systems).

**SYSTEMS ANALYSTS**—should be graduate physicists or engineers with a minimum of three years experience in weapon systems analysis, operation analysis, IR, physics of space, signal processing or communication theory. Involves the consideration of many basic problems such as: the proper mix of manned vs. unmanned satellites; the requirements of manned space flight; justification of system choice in terms of cost effectiveness; automatic target recognition requirements for high speed strike reconnaissance systems or unmanned satellites; IR systems requirements for ballistic missile defense; signal processing techniques for interplanetary telecommunications; analysis of weapon systems from conception through development, test and customer use; design concepts for new airborne weapon systems.

**CIRCUIT DESIGN ENGINEERS**—should be experienced systems engineers capable of analysis and synthesis of systems involving the following types of circuits and components: high power airborne radar transmitters; low noise radar receivers using parametric amplifiers, solid state masers and other advanced microwave components; radar data processing circuit design, including range and speed trackers and crystal filter circuitry; high efficiency power supplies for airborne and space electronic systems; telemetering and command circuits for space vehicles; timing, control and display circuits for COLIDAR (Coherent Light Detection and Ranging).

**INFRARED SPECIALISTS**—to perform systems analysis and preliminary design in infrared activities involving satellite detection and identification, air-to-air missiles, AICBM, infrared range measurement, air-to-air detection search sets, optical systems, detection cryogenics and others.

**Immediate openings** also exist for Power and Propulsion Engineers, Analytical and Design Engineers, Structures Engineers, Heat Transfer Engineers, Equipment Installation Engineers, Electromagnetic Theory Specialists and Antenna Specialists.

Reply today: Your inquiry will be treated with strict confidence. Please airmail your resume to: **Robert A. Martin,** Supervisor of Scientific Employment, Hughes Aircraft Co., 11940 West Jefferson Blvd., Culver City 36, California.

*WE PROMISE YOU A REPLY WITHIN ONE WEEK*

**SEPARATION SYSTEM** – A new separation system is based upon the development of a frangible nut and integral dual explosive train. In a typical operation, according to **Special Devices, Inc., Dept. S/A, 16830 W. Placerita Canyon Rd., Newhall, Calif.**, the nuts are torqued to bolts joining two missile stages, normally eight to twelve bolts. Prior to launch or firing, the dual explosive-harness is placed in position and inter-connects all frangible nuts in the system.

No. 312 on Reader Service Card

**FILTER ASSEMBLY** – A line of low pressure filter assemblies for a wide range of fluid system applications is now available from **Bendix Filter Div., The Bendix Corp., Dept S/A, 434 W. 12 Mile Rd., Madison Heights, Mich.** Typical uses include hydraulic power systems, industrial air line systems, diesel fuel systems, pneumatic power systems, and lubricating oil systems. The units are rated at 150 psi operating pressure at 100 deg F.

No. 313 on Reader Service Card

**TIMER MOTOR** – A unique method of sealing all moving parts in oil is featured in this synchronous timer motor. Developed by **Lake City, Inc., Dept. S/A, 11 W. Woodstock, Crystal Lake, Ill.**, complete sealing is reported effected by a specially designed, spring loaded packing gland which prevents the oil from working out of the housing during operation. One of the smallest timer motors ever developed, it measures 1-$^{11}/_{16}$ in. outside diameter.

No. 314 on Reader Service Card

**CONTROL UNIT** – Precision control packages for electronic equipment or other temperature sensitive applications are now available from **Lytron, Inc., Dept. S/A, 42 Brookford St., Cambridge 40, Mass.** The units can maintain constant temperatures from −30 to +120 deg F. to ±0.1 deg F in 0 to 800 Btu/hr and 0 to 24000 Btu/hr heat lead ranges They measure 21 x 12 x 6 inches, weigh 38 lb, and are rated at 2.2 kw, 115 volts, 60 cps.

No. 315 on Reader Service Card

**GAS GENERATOR** – This gas generating power source is small enough to be held, transported, and operated by hand. According to **Aircraft & Missile Consultants, Dept. S/A, 2722 Ardmore Ave., Manhattan Beach, Calif.**, it can be used to produce cool gas to inflate units from 1 to 500 cubic feet, at pressures from 3 to 3000 psi. As an auxiliary power system, it will provide high pressure gas to operate pneumatic tools.

No. 316 on Reader Service Card

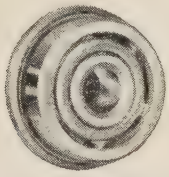


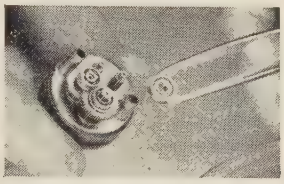
No. 115 on Reader Service Card

# BARDEN PRECISION BALL BEARINGS

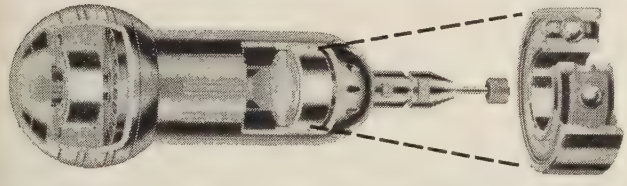
If your product needs bearings with close mounting tolerances, high geometrical accuracy, low torque or low vibration . . . if it operates at high speeds or high temperatures . . . specify *Barden Precision.*

For less difficult applications, the consistent quality, predictable performance and reliability of *Barden Precision* ball bearings can cut your assembly time, rejection rates and teardown costs.

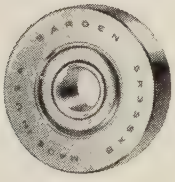




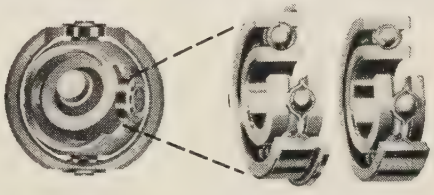
**For gear trains:** Barden standard low torque bearings with closely controlled radial play and low eccentricity assure minimum backlash. Precision flanges provide accurate positioning surfaces and permit through-boring, eliminating the need for housing shoulders and reducing manufacturing and assembly costs. Sizes from .1562″ to .8750″ O.D.



**For power tools,** aircraft and missile accessories, and other high speed applications: Barden "T" retainer bearings with high load capacity and long, trouble-free life. Double shielded, grease lubricated "T" retainer bearings have operated more than 6,000 hours at 80,000 RPM. Sizes from .5000″ to 3.3465″ O.D.

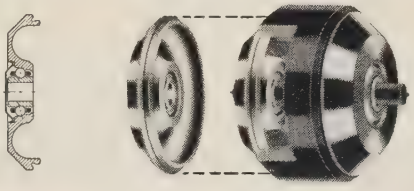


**For synchros:** Volume produced precision bearings with extra-large outer rings designed to serve as end caps, thereby reducing synchro complexity and cost and increasing air gap accuracy. Barden-developed synchro bearings have closely controlled radial play and minimum eccentricity to meet tight air gap specifications. Sizes from .3750″ to 2.0000″ O.D.



**For gyro gimbals** and other torque-sensitive devices: Barden "W" retainer reduces torque peaks and eliminates retainer lock. "W" retainer bearings save one gyro manufacturer $100 per unit by reducing costly teardown. Sizes from .1562″ to .6250″ O.D. Also other standard and special design gimbal bearings, including the Barden Dynamic Bearing with near-zero torque.

**For gyro rotors:** Barden special design end-bell bearings to increase accuracy and reduce assembly cost of miniature gyros. Bearings become part of spin mass and serve as end caps for wheel assembly, reducing mating part errors and improving squareness, concentricity and overall accuracy. Sizes from .615″ to 1.016″ O.D. Also other standard and special types including inertial gyro bearings with 20-microinch tolerances.



**For memory drums,** high precision spindles and other low runout applications: Barden duplex pairs with extremely low eccentricity and non-repetitive runout. Matched pairs with accurately controlled preload provide high load capacity, smoothness and long life along with radial and axial rigidity. Sizes from .3125″ to 3.3465″ O.D., deep groove or angular contact.

Major manufacturers of instruments, mechanical components, computers, spindles and aircraft accessories regularly specify *Barden Precision* ball bearings for high performance mechanisms.

To specify *Barden Precision* ball bearings—prototype, pilot run or large volume production—ask for a Barden sales engineer to give you on-the-spot assistance, or write for Catalog C-3.

*for reliability... specify*

BARDEN PRECISION BALL BEARINGS

THE BARDEN CORPORATION, 220 Park Ave., Danbury, Conn. · Pioneer 3-9201
Western Office: 3850 Wilshire Blvd., Los Angeles 5, Calif. · DUnkirk 5-0034

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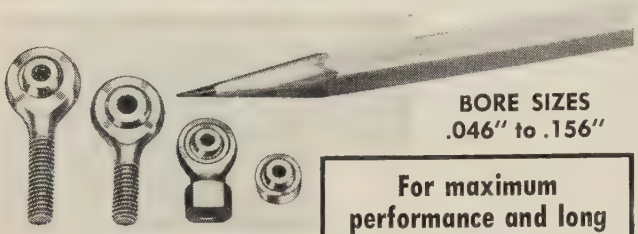
Now SOUTHWEST "Monoball"®
ultra-precision
MINIATURE
Self-Aligning Spherical Bearings



BORE SIZES
.046" to .156"

ULTIMATE STATIC LOADS
225 lbs. to 2550 lbs.

For maximum performance and long life in compact, lightweight assemblies

Miniature "MONOBALL"® self-aligning, plain and rod end bearings are now available in volume! The "BMP" Series was developed in 1949 and has been used in a wide variety of small precision assemblies demanding high performance and long life with minimum size and weight. Available only in stainless steel.

Consultation is invited. Southwest's newly expanded Research and Development Facility staff can design special types for your particular problem. Write for Bulletin No. 461. Address Dept. S/A 61

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SOUTHWEST PRODUCTS CO.
1705 So. Mountain Ave., Monrovia, California

No. 117 on Reader Service Card

PERFORMS
36 TIMES LONGER
AT 1,000°F
THAN ANY OTHER
LUBRICANT!

General Magnaplate's HI-T-LUBE* is a dry film lubricant that actually provides a lower coefficient of friction as pressure increases... and an almost constant coefficient of friction at temperatures ranging from —100° to +1,500°F. Its performance under high loads, at high temperatures, enabled G. E. to crack the supersonic thermal barrier under these conditions: temperatures to 1,000°F, applied load of 1,400 lbs. rotating at 720 rpm, reversing direction every 3 seconds... HI-T-LUBE* performed effectively for 3 hours where other lubricants failed in less than 5 minutes! Other tests proved its fast heat dissipation, adherence under all conditions, ruggedness and permanence. For all the facts, write today!

*Trade-Mark

GENERAL
MAGNAPLATE
CORPORATION
328 Main St., Belleville, N. J. • PL 1-1500

No. 118 on Reader Service Card

**FASTENER** – A resilient nylon pellet imbedded in the threaded area of this fastener supplements the locking action of the O-ring under the head, and provides increased protection against shock and vibration. Developed by **A.P.M. Corp., Dept. S/A, 41 Honeck St., Englewood, N.J.**, the "Nylock" features provides added reliability and thread locking action. This high-pressure fastener can be removed and re-used without affecting the sealing action. It has been approved by the military under Mil-F-18240 for tapped holes in place of locked-wire screws and bolts.

No. 317 on Reader Service Card

**SOLID STATE ALARM** – This alarm unit is used to monitor over-limit conditions of low level input sensors such as thermocouples, strain gages, etc. Critical deviations from set limits show up as a visible and audible signal, says the **San Diego Scientific Corp., Dept. S/A, 3434 Midway Drive, San Diego 10, Calif.** Separate alarm circuits are used for each input. Typical performance specs: 0-25 mv input range, 1000 ohms min input resistance, 2 mv min and 15 mv max between high and low set points.

No. 318 on Reader Service Card

**TEMPERATURE PROBE**—A precision temperature probe suitable for liquid, vapor, and gas applications in aircraft and missiles is manufactured by **Quantatron, Inc., Dept. S/A, Instrumentation Div., Los Angeles 66, Calif.** The Model R146 probe is described as a continuous-resistance output transducer, completely encased in a rugged one-piece 303 stainless steel corrosion-resistant housing that eliminates leakage. Its sensing element is a stabilized alloy wire that converts temperature changes into electrical signals for transmission to a remote device. Measurement range is —100 to 400 deg F with calibration accuracy of better than ±5 deg F in the standard unit.

No. 319 on Reader Service Card

**DC POWER SUPPLY**—A miniature, transistorized, regulated DC power supply which conforms to Mil-T-21200 and Mil-E-4970 specs has been developed recently. The unit operated from 115 V AC at 400 cps and produces very closely regulated 12 V DC at up to seven amp. Ripple and noise level is less than 100 mv peak-to-peak, and output impedance is less than 0.025 ohms at 400 cps, says **Kaiser Electronics, Inc., Dept. S/A, 1160 Monroe St., Union, N. J.** The power supply features a noninductive filter, self-protecting circuits, and continuous operation at 55 deg C, without external forced air cooling. The aluminum housing dissipates a maximum amount of heat.

No. 320 on Reader Service Card

**PITOT STATIC TUBE**—Accurate static pressure for subsonic and supersonic flight is provided from a single pair of static pressure ports in a pitot static tube developed by **Rosemount Engineering Co., Dept. S/A, 4900 W. 78 St., Minneapolis, Minn.** In addition to eliminating the need for separate pressure inputs, this unit reportedly avoids the need for large computed corrections. This model 855 tube has a standard rear portion configuration, while the forward portion is modified by increasing the outside diameter slightly in the vicinity of the static port. The amount of increase and degree of taper depends on the aircraft nose and boom configuration.

No. 321 on Reader Service Card

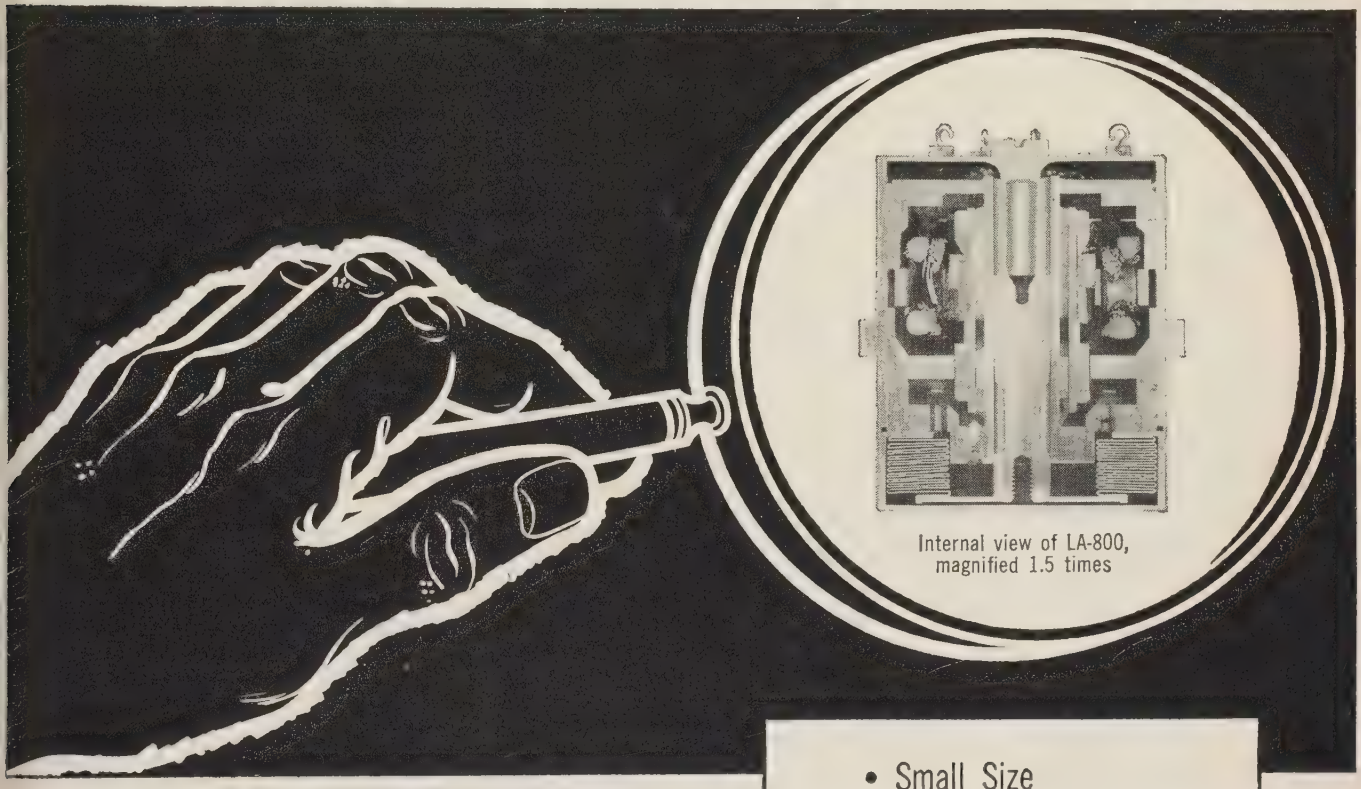
# BIG ACCELEROMETER PERFORMANCE IN A SUBMINIATURE PACKAGE!

The LA-800 Series is the smallest non-pendulous linear accelerometer available today featuring a variable reluctance pickoff and essentially constant damping over the temperature range of −65°F to +250°F. It is the smallest instrument of its type that can measure acceleration forces up to 80 G.

Reliability through overall simplicity was the primary goal of the LA-800 design. An example is the seismic mass support which eliminates sleeve bearings and their inherent friction. The result of this basic design objective is an accelerometer which can be relied upon to operate instantaneously and for long periods, even after months of storage.

The combination of miniaturization, ruggedness, and high performance makes this instrument ideally suited for advanced aircraft and missile applications where space and weight considerations are critical.

Write for Technical Bulletin BM-SLA8-1 to Minneapolis-Honeywell, Boston Division, Dept. 16, 1400 Soldiers Field Road, Boston 35, Mass., or call your local Military Products Group Office. Sales and Service offices in all principal cities of the world.



Internal view of LA-800, magnified 1.5 times

Subminiature Accelerometer LA-800, shown ¾ size

**PERFORMANCE DATA**

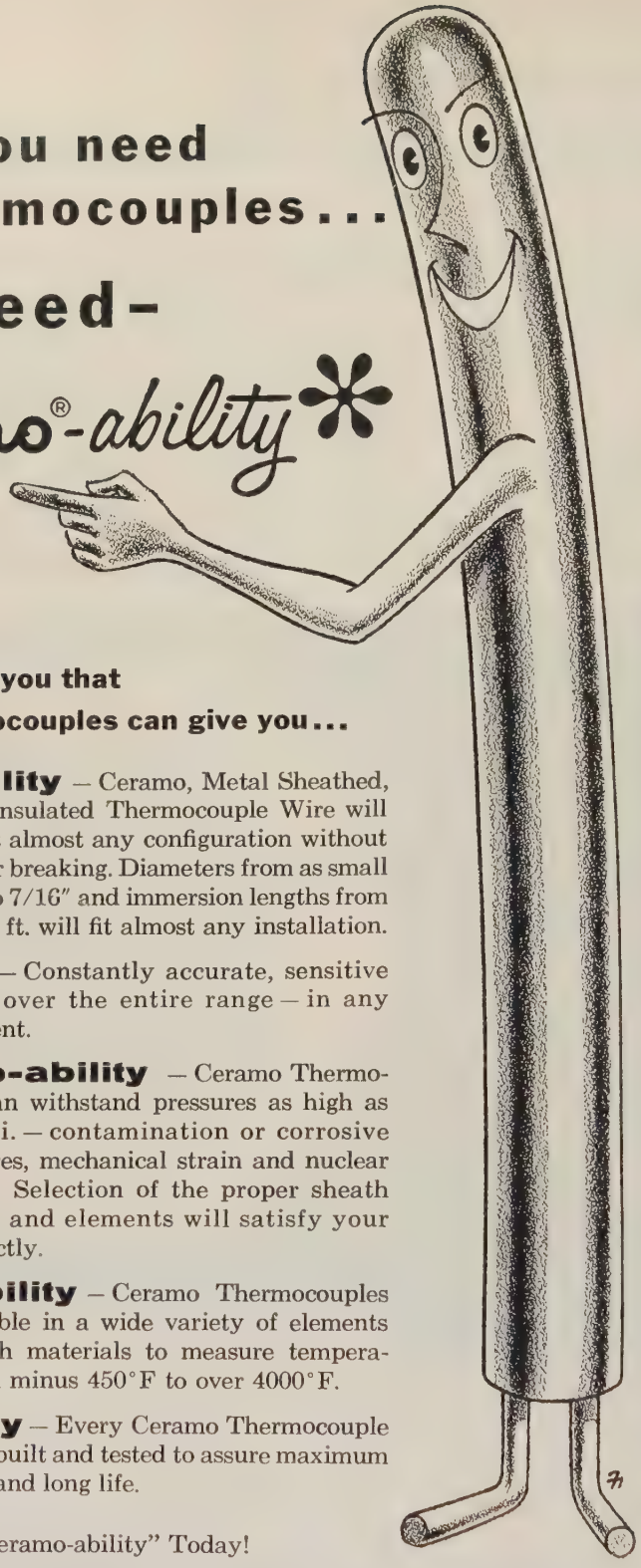
- **SIZE:** 1 inch in diameter by less than 1.5 inches (over terminals)
- **WEIGHT:** Approximately 3 ounces
- **DAMPING RATIO:** Any nominal ±20% from −65°F to +250°F
- **RANGE:** Up to 80 G
- **PICKOFF:** Variable Reluctance design provides infinite resolution and high signal-to-noise ratio
- **LOW THRESHOLD, EXCELLENT RESOLUTION:** $10^{-4}$G
- **EXCELLENT LINEARITY:** ±0.5% to half-scale; ±2% to full-scale
- **LOW HYSTERESIS:** Less than 0.15% full scale
- **LINEAR ACCELERATION:** 10 G's or 3 times full-scale, whichever is greater.
- **LINEAR VIBRATION:** 15 G's to 2 kc for low G units; 30 G's to 2 kc for high G units

**Consult Honeywell for your specific linear accelerometer requirements**

- Small Size
- Simple Construction
- Reliable
- Self-Test Available

**Honeywell**

Military Products Group



**When you need Thermocouples...**

**You Need-**

**Ceramo®-ability***

**Let us prove to you that**
**Ceramo Thermocouples can give you...**

***Adaptability** – Ceramo, Metal Sheathed, Ceramic Insulated Thermocouple Wire will bend to fit almost any configuration without shorting or breaking. Diameters from as small as 1/25" to 7/16" and immersion lengths from 1/2" to 70 ft. will fit almost any installation.

***Stability** – Constantly accurate, sensitive response over the entire range – in any environment.

***Stand-up-ability** – Ceramo Thermocouples can withstand pressures as high as 50,000 psi. – contamination or corrosive atmospheres, mechanical strain and nuclear radiation. Selection of the proper sheath materials and elements will satisfy your needs exactly.

***Rangeability** – Ceramo Thermocouples are available in a wide variety of elements and sheath materials to measure temperatures from minus 450°F to over 4000°F.

***Reliability** – Every Ceramo Thermocouple is quality built and tested to assure maximum efficiency and long life.

Find Out About "Ceramo-ability" Today!

**WRITE FOR YOUR 48-PAGE THERMOCOUPLE CATALOG TC-2**

—information on all Thermo Electric Thermocouples and accessories.

Thermo Electric

THERMO ELECTRIC Co., Inc., Saddle Brook, New Jersey
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

20 YEARS • *Temperature Measuring Systems and Components*




**PROPELLANT BINDER** – DPR, a natural crude rubber composed of 100 per cent solids in flowable form for compounding propellant binders, is made available by **DPR Inc., Dept. S/A, Belleville 9, N. J.** The material is a moisture-free, viscous liquid; viscosity at 100 deg F is between 35,000 cps and 200,000 cps. The product is available based on either natural or synthetic rubber. Properties of both are essentially equal. The material has a low coefficient of thermal expansion and excellent bonding properties.

No. 322 on Reader Service Card

## DATA FILE

**DIAPHRAGM**—A bulletin listing approximately 1200 standard sizes of rolling diaphragms in bore-sizes from 0.31 to 12.17 inches is available from **Bellofram Corp., Dept. S/A, Blanchard Rd., Burlington, Mass.** Tables show diaphragm class, cylinder bore, piston diameter, effective-pressure area, and side-wall thickness.

No. 323 on Reader Service Card

**FACILITY**—Manufacturing and assembly capabilities for components for military use are described in a brochure from **Pioneer Tool & Engineering Co., Dept. S/A, 7401 W. Lawrence Ave., Chicago 31, Ill.** The brochure lists manufacturing equipment, inspection facilities and describes components the company has manufactured.

No. 324 on Reader Service Card

**GYRO**—A two-page data sheet describing the Series 1078 floated rate integrating gyro for severe environmental applications is available from **Lear, Inc., Dept. S/A, 110 Ionia Ave., N.W., Grand Rapids 2, Michigan.** Engineering data, features and a typical installation drawing are included in the data sheet.

No. 325 on Reader Service Card

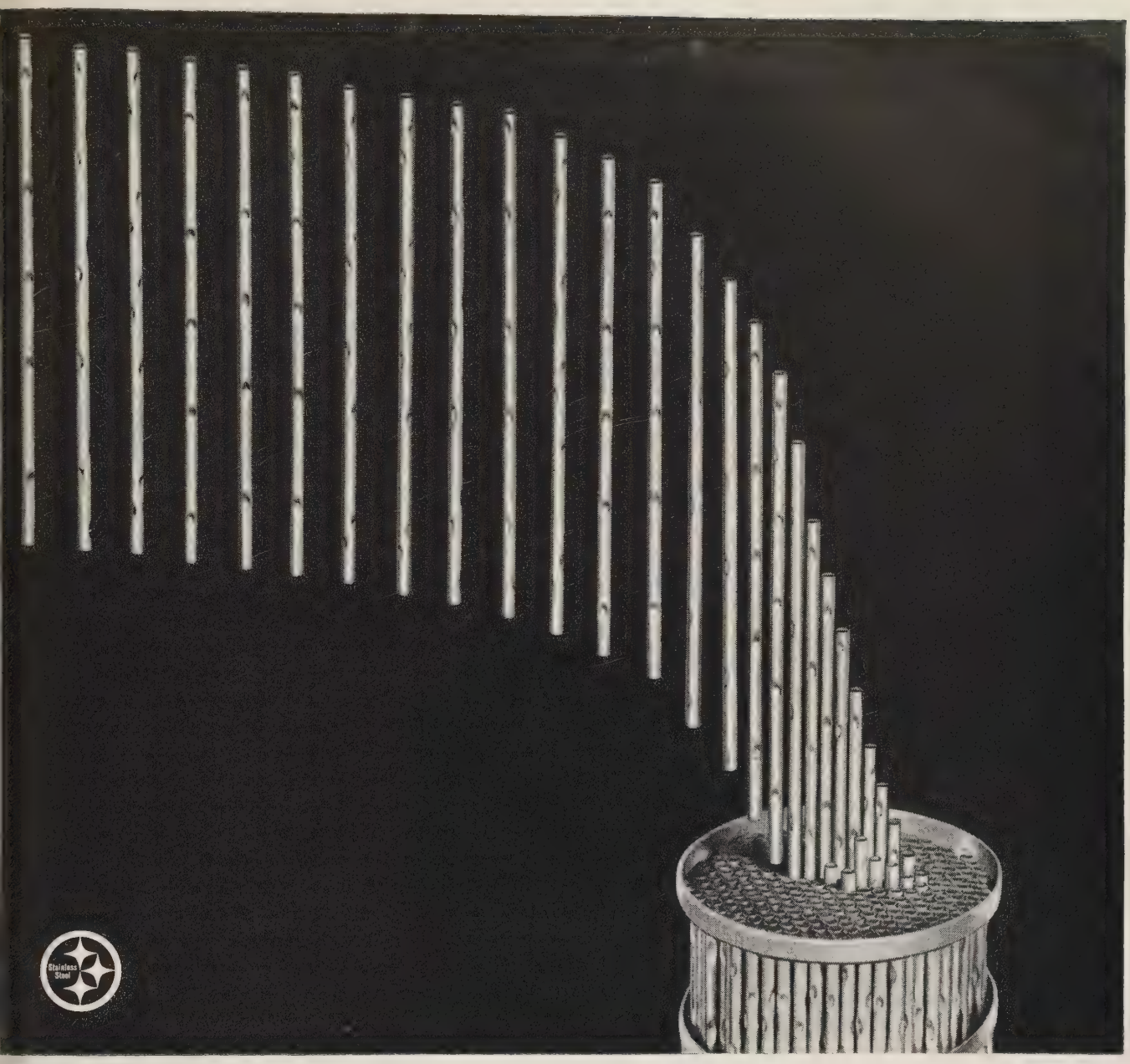
**DIAPHRAGM VALVES**—Bulletin 134-A providing data on eight types of air operators for diaphragm valves for control of liquids and gases is available from **Hills-McCanna Co., Dept. S/A, 400 Maple Ave., Carpentersville, Ill.** Sectional drawings, descriptive information, tables of air actuator pressures for various line pressures and ordering instructions are given.

No. 326 on Reader Service Card



No. 120 on Reader Service Card

*Tomorrow's tubing technology—today*



# Light as a feather with wafer-thin walls, Superior tubing works magic for aircraft heat exchangers

Look to Superior for miniature heat-exchanger tubing with the reliability that assures fast, efficient heat transfer, reduction in weight, and consistently safe performance. We make it from a wide selection of stainless steels, including Types 304, 310, 316 and 347, plus two low-carbon analyses, Types 304L and 316L, which minimize carbide precipitation and have improved corrosion resistance. We hold it to extra-close tolerances—one-half commercial tolerance, or closer, when specified. ODs as small as 5/32 in. and walls as thin as .004 in. can be produced. It is carefully inspected—statistical sampling, 100% inspection or nondestructive testing, if required. It is 100% pressure tested and statistically flare tested as standard practice. Produced in a number of different shapes—squares, rectangles, ovals, ellipses, etc.—to meet the latest aircraft heat exchanger design requirements.

Write for Bulletin 372—it gives detailed information on all types of Superior tubing for aircraft, missile and rocket applications. For other small-diameter tubing requirements, Superior produces more than 120 analyses in sizes from .010 to 5/8 in. OD in quantities, large or small, to meet your requirements. Superior Tube Co., 2038 Germantown Ave., Norristown, Pa.

**Superior Tube** (ST)

The big name in small tubing

***NORRISTOWN, PA.***

*West Coast: Pacific Tube Company, Los Angeles, California*

No. 121 on Reader Service Card

NOW...FROM WINSLOW

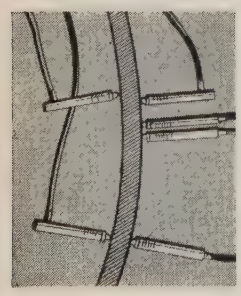
**New electronic gaging systems**

CUTS READING ERRORS

NO RECORDING ERRORS

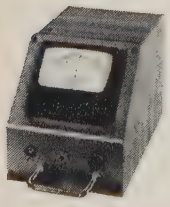
NO VISIBILITY PROBLEMS

CUTS ACCESS PROBLEMS

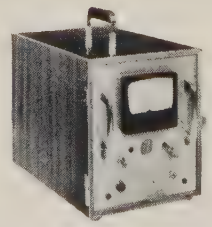


Uses Winslow Electronic Gaging Probes—sensitive transducers that substitute for standard dial indicators and most air probes in any mechanical "design" gage. Small size of the Probes (3/8" dia. x 2-13/32") allows locating check points where never possible before. Probes can be completely hidden. Console CS-24 (above) shows gage position and variation in lighted numerals 1" high, also prints this information on tape, card or sticker if desired. Push proper button to check any individual point, or machine automatically reads up to 24 gage positions and prints the results. Also reads "thickness" variation between any two opposed Probes. Accuracy possible to nearest .0001". Versatile—use with any number of "design" gages. Write for literature.

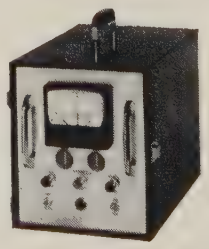
**ALTERNATE READOUT DEVICES**



Model IN-27 reads out a single Probe on meter scale. Can operate automatic sorting devices, etc. Can be ganged to read multiple points simultaneously.



Model LP-9 Electro-Chek* reads each of 9 Probes on the meter as you touch the button. Lighted digital lamp identifies gage position. Optional limit pointers.



Model LP-18 Electro-Chek* reads up to 18 contour points. Also reads "thickness" variation between any two opposed Probes. Compact. Versatile.

*T.M. Winslow Mfg. Co.

ACCURACY THROUGH ELECTRONICS

WINSLOW

MANUFACTURING CO.

1751 EAST 23 STREET • CLEVELAND 14, OHIO




**ABRASIVE CONTAMINANTS**—In a research report, **The Electrolizing Co., Dept. S/A, Chicago Heights, Ill.**, gives an analysis of parts failure caused by nonmetallic abrasive contaminants on bearing surfaces. It includes many photomicrographs showing the scatter, size, and incidence of nonmetallic particles observed on typical failed parts. Other photos show the results on components after conventional and ultra-sonic cleaning and after Multi-Cleaning and Electrolizing.

No. 327 on Reader Service Card

**LUBRICATION**—The use of Drilube, a dry film lubricant, is covered in literature issued by **Drilube, Dept. S/A, 723 W. Broadway, Glendale 4, Calif.** In other literature, the company gives information on their Oxylube, developed to solve lubrication problems involving liquid oxygen or other high energy propellants.

No. 328 on Reader Service Card

**DIAPHRAGMS**—Elastomer-fabric diaphragms are described in a 4-page brochure available from **Diaphragm Industries, Inc., Dept. S/A, 102 Rantoul St., Beverly, Mass.** Long stroke, rolling, preconvoluted, and molded convoluted diaphragms for either static or dynamic use in aircraft are described and illustrated. Mechanical data such as sidewall thickness, flange and bead construction, etc., are illustrated. A design worksheet is provided to facilitate need analysis.

No. 329 on Reader Service Card

**THREE-WAY VALVE**—A diaphragm operated, snap acting, three-way valve is described in a bulletin issued by **G. W. Dahl Co., Inc., Dept. S/A, 86 Tupelo St., Bristol, R. I.** It gives applications, description, and specifications for this Mite 75 valve. A scaled cutaway drawing showing operation of the valve, together with a list of materials, is also included in the bulletin.

No. 330 on Reader Service Card

**COUPLING**—Almost 500,000 different combinations of quick connect/disconnect couplings can be selected from a new catalog issued by **Snap-Tite, Inc., Dept. S/A, Union City, Penna.** Construction details are illustrated, with a generous use of cutaway drawings. Complete dimensional and weight data are shown on gatefolds. Working pressures, flow, pressure drop, and spillage data are given for each product.

No. 331 on Reader Service Card



No. 122 on Reader Service Card

No. 165 on Reader Service Card

# your map in a **UNIVERSE** of AIRCRAFT PUMPS

*This new engineering bulletin leads you right to the hydraulic pump designs you may be looking for. Here, passing on parade, are high performance gear pumps made to the measure of the next generation in aircraft, missiles, spacecraft, and support equipment.*

*Many of these units are the product of ready-made, mass-produced components that can be teamed into the precise configuration you need. Custom-designed pumps are also available.*

All have in common these classic Eastern hydraulic pump characteristics:

SMALL SIZE: Eastern gear pumps are the smallest, lightest made. Airborne servo system pump shown delivers 1.5 gpm @ 1500 psig — measures only 1⅞" x 1⅞" x 2¾", weighs 9 oz.

WIDE PERFORMANCE RANGE: pumps available have theoretical displacement from .0016 to 1.30 cu. in. per revolution — flow from .025 to 9.6 gpm, pressures from 0 to 2000 psig, at speeds to 24,000 rpm. Weights with motor range from 1.5 to 8.5 lbs.

UNAFFECTED BY EXTREME ENVIRONMENTS: rugged, reliable Eastern units take loads to 50g in stride — shrug off temperature differentials to meet MIL specs.

Eastern AVIATION PRODUCTS

## EASTERN INDUSTRIES INCORPORATED

100 SKIFF STREET • HAMDEN 14, CONNECTICUT
WEST COAST OFFICE • 4203 SPENCER ST. • TORRANCE, CALIF.

**Other Eastern products:**
- hydraulic motors
- servovalves, amplifiers, actuators and systems
- pressurization/dehydration packs
- quick-disconnect couplings
- electronic tube cooling units

**TRANSDUCER**—An electric pulse output type transducer is discussed in a data sheet prepared by **Hydropoise, Inc., Dept. S/A, 230 S. Wells Fargo Drive, Scottsdale, Ariz.** Diagrams in the data sheet include a demonstration of the balancing effect of the pressure feedback system. The transducer is reported applicable to any liquid or gas, and will withstand line pressure up to 5000 psi.

No. 332 on Reader Service Card

**JEWELS**—An 8-page manual covering jewels, jewel bearings, pivots and other jewel products has been issuel by **Moser Jewel Co., Dept. S/A, 544 Fayette St., Perth Amboy, N. J.** It gives properties and types of jewels and precision metal parts, characteristics of jewel bearings, types of jewel assemblies, settings, selection factors, and possible industrial applications.

No. 333 on Reader Service Card

**BATTERIES**—The characteristics of sealed silver-cadmium batteries are described in a paper released by **Yardney Electric Corp., Dept. S/A, 40-50 Leonard St., New York 13, N.Y.** The sealed units are available in a standard line ranging from 0.1 to 300 ampere hours, encapsulated individually or as composite units for greater volumetric efficiency.

No. 334 on Reader Service Card

**SUBMINIATURE RELAYS**—A line of relays, designated Ugon series, for guided missile applications, are detailed in a data sheet by **Vactric Control Equipment, Ltd., Dept. S/A, 30 Bouverie St., London, England.** It covers performance details, wiring connections and mounting configurations.

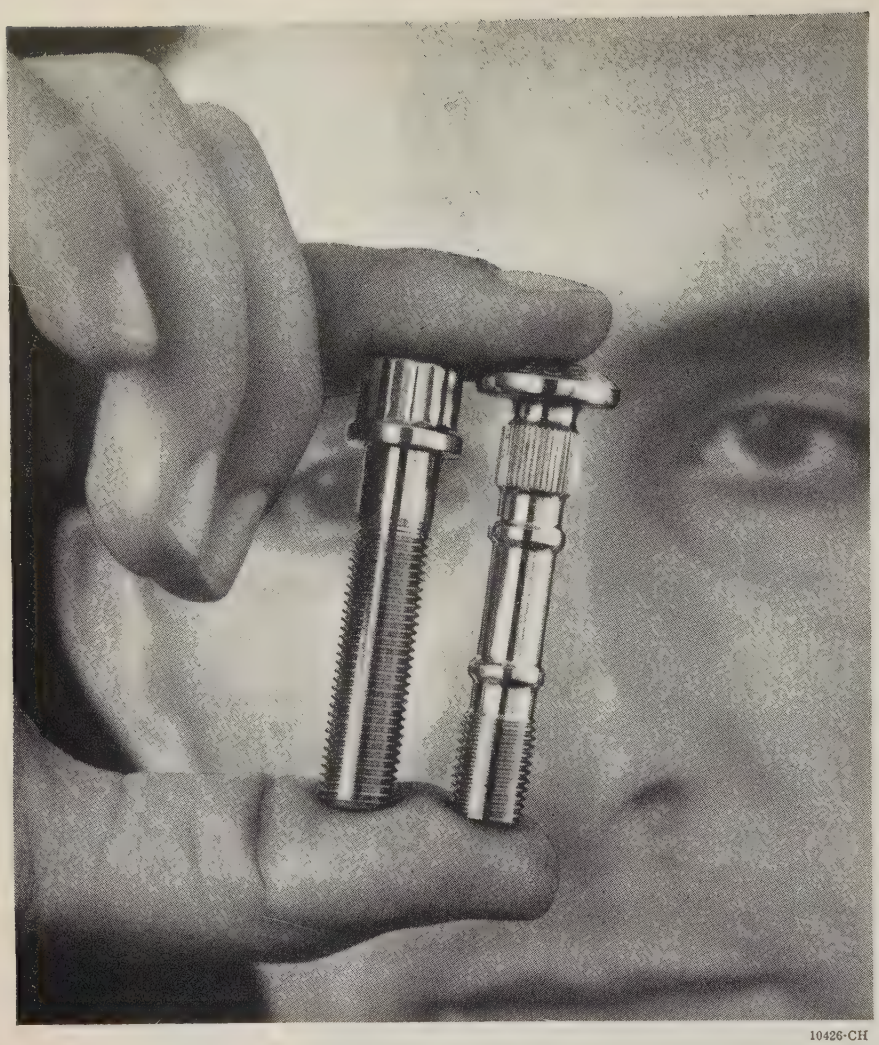
No. 335 on Reader Service Card

**CONTACTS**—A "Basic Guide to Electrical Contacts" has just been published by **Tricon Manufacturing Co., Dept. S/A, 8010 S. Wallace, Chicago, Ill.** The eight-page bulletin includes charts covering applications and technical data for various contact alloys and specifications of the most commonly employed stock contacts.

No. 336 on Reader Service Card

**HEAT TRANSFER**—A "Heat Transfer Design Manual" just released by **Electrofilm, Inc., Dept. S/A, 7116 Laurel Canyon Blvd., No. Hollywood, Calif.** gives graphical solutions to all types of heat transfer problems such as heat transfer off surfaces by a combination of free convection and radiation. The heat design manual also contains data on heat transfer coefficients and specific heat and thermal conductivities.

No. 337 on Reader Service Card



10426-CH

How *critical* can you be in your selection of a fastener for a special application . . . especially when extreme accuracy, reliability and consistent performance are specifications. For over thirty years, Chandler has been producing special fasteners and standard cap screws and bolts that meet these demanding requirements.

If you have a special fastener problem . . . here's what you can expect from Chandler. *Into the design* of your special fastener goes the knowledge of expert Chandler engineers . . . careful attention to detail and exhaustive testing to meet critical standards . . . advanced production methods to assure on-time delivery . . . RESULT . . . a precise fastener, custom-tailored and mass-produced at the most favorable cost.

Next time . . . Check with Chandler . . . FIRST.

*Write today for your Chandler catalog.*

CP

**chandler** Products Corporation

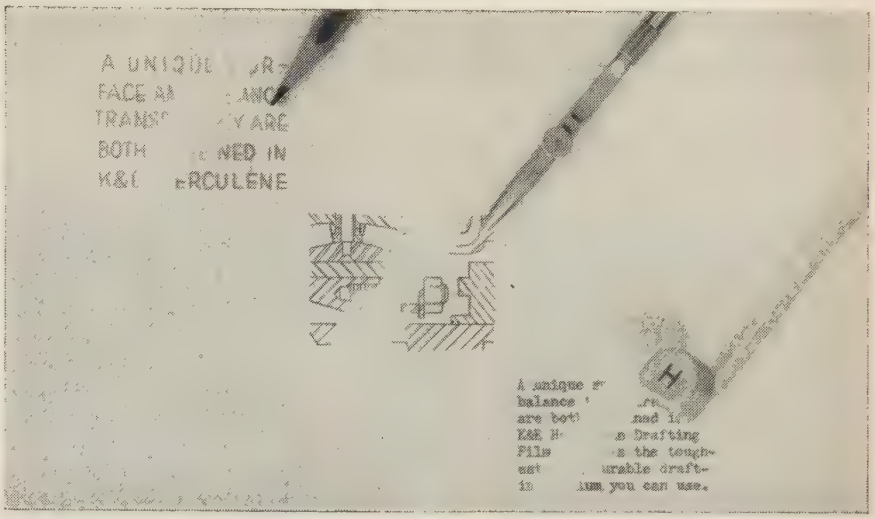
1493 Chardon Road • Cleveland 17, Ohio

No. 123 on Reader Service Card

# Some Ideas

for your file of practical information on drafting and reproduction from

**KEUFFEL & ESSER CO.**



Six years ago, K&E introduced the very first polyester-base drafting film—a special-purpose medium featuring extreme dimensional stability. Experience with that film indicated that a definite need also existed for a *general-purpose* drafting film, if one could be perfected. About two and a half years ago we succeeded, introducing HERCULENE® Drafting Film—the first polyester-base medium for general drafting to meet professional standards. Many recognized its value immediately, stocked up on HERCULENE, and have used it happily ever since. Others—a bit more "canny" about adopting a relatively untried medium—deferred decision, saying "see us in a year or so." Still others—having tried one or more of the other films marketed immediately after HERCULENE—seemed permanently disenchanted with *all* film based media. What with the passage of time and much favorable ado about drafting films in general, we rather think that those once stung may now have adopted a more congenial attitude—so we address ourselves solely:

**To fence-sitters everywhere . . .**

Just as we felt in '58, we feel today, that film has an important place in the drafting room. The only difference now is that experience has *proved* it so. Since 1958, the number of HERCULENE users has grown by leaps and bounds. All, we're happy to say, have found HERCULENE a welcome, efficient, and *much needed* addition to their stock of drafting media. It is these HERCULENE users who have written the record. Their many and rigorous tests, their months of experience, their numerous successes and continuing satisfaction are convincing evidence that HERCULENE is all we said it would be.

**Why all the fuss about HERCULENE? . . .**

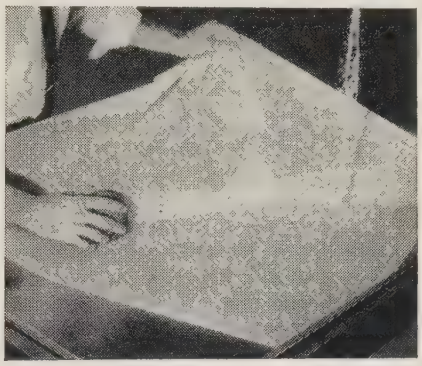
HERCULENE combines practically all the qualities of a perfect drafting medium. An excellent product when introduced, it's even closer to perfection today. Working with major film users, K&E specialists have refined HERCULENE in many subtle ways since its introduction.

Unlike cloth or paper, HERCULENE is virtually indestructible. No matter how roughly or frequently a HERCULENE tracing is handled, it will never crack, wrinkle or fade. Absolutely waterproof, a HERCULENE drawing can never be permeated and ruined by moisture. Filed away, HERCULENE will last indefinitely. And HERCULENE has body, too, making it far easier to handle and file, and to keep flat on the drawing board.

Most of the refinements made in HERCULENE since 1958 have concerned its engineered drafting surface. HERCULENE's surface "take" for pencil, ink and typing is now better than ever. Erasability, of course, is excellent for all three. Contrast has been built up for sharper definition of line, too, yet all the transparency necessary for fast, clear reproductions has been maintained.

**Two big bonuses, too . . .**

A significant chapter in the HERCULENE story has been the development of a waterproof writing mate—the Duralar plastic pencil. Drawings made on HERCULENE with this waterproof pencil can actually be



washed in soap and water. Even gray, grimy "unreproducible" drawings can be washed spotless with this new technique. Many firms now use the HERCULENE/Duralar team exclusively . . . and are realizing undreamt-of savings in costly re-draws.

Some firms, of course, by virtue of smaller work volumes and "cleaner" or less frequent handling, will have little need for this new wash technique. Of particular interest here is another K&E exclusive recently introduced—the amazing Ruwe pencil. The Ruwe pencil will not withstand washing, but in every other respect, this new pencil is graphite-*plus*. Although of plastic composition, the Ruwe pencil has all the "fine" feel of graphite, erases well, and deposits a sharp, dense black line. The big bonus: Ruwe pencil lines are *virtually smudge-proof*. Rendered on HERCULENE's engineered drafting surface, they actually resist smudging better than graphite on regular paper!

**We leave it to you . . .**

The best test remains the one you make for yourself. We've just completed a new brochure, titled "A Report on the Growing Acceptance of Polyester Film." In it is detailed most of what we have learned about HERCULENE and its use since 1958—including tests you can make to assess its every property. We'd like you to have a copy of this new brochure—plus a sample sheet of HERCULENE, a Duralar pencil, and a Ruwe pencil—for your own private testing. To get these free samples, simply fill out and mail the coupon below:

**KEUFFEL & ESSER CO.,** Dept. AA-11, Hoboken, N. J.

Gentlemen:

Please send me your new brochure, titled "A Report on the Growing Acceptance of Polyester Film," a sample sheet of HERCULENE Drafting Film, and samples of the Ruwe and Duralar Pencils.

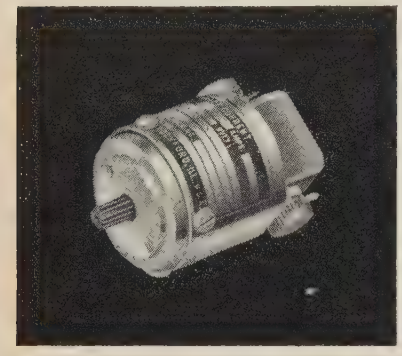
Name & Title _____

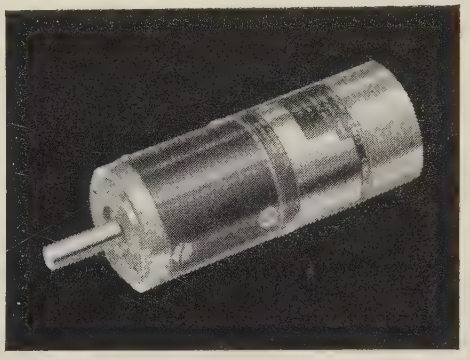
Company & Address _____

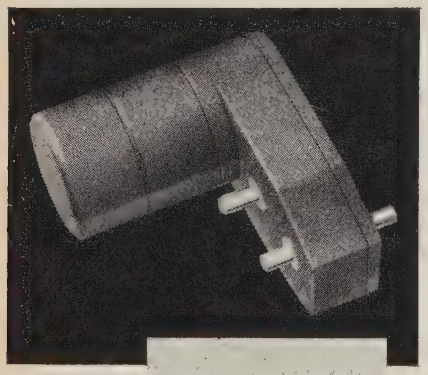
_____

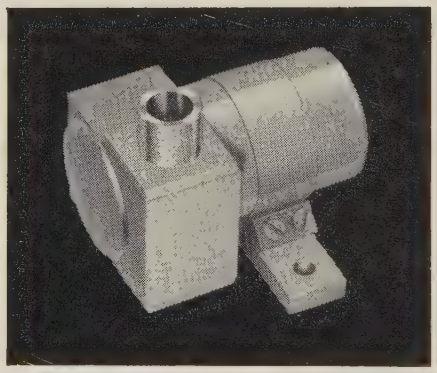
No. 124 on Reader Service Card

*Precision permanent magnet reversible motors...gearheads, blowers, and right-angle drives...for airborne and industrial applications*









THE MARK OF QUALITY

BARBER COLMAN

VOLTAGES FROM 6 V d-c TO 115 V d-c

WITHSTAND AIRCRAFT AND MISSILE AMBIENTS

STABILIZED MAGNETS...UNDAMAGED BY INSTANTANEOUS REVERSALS

SMOOTH RUNNING...LOW COGGING AND RIPPLE

## d-c small motors

Barber-Colman offers a large selection of compact, high-quality d-c motors with outputs up to 1/10 hp. Compact design . . . 1¼″ to 1½″ diameters. Various mountings and speeds . . . several sizes and styles of gearheads and blowers. Integral radio noise filters, magnetic brakes, and governors available for most basic designs. Right-angle drives and multiple-shaft outputs also available for special applications.

WRITE FOR NEW QUICK REFERENCE FILE on the complete line of Barber-Colman electrical components. Includes detailed specifications on a-c and d-c motors, tach generators, blowers, gearheads, relays.

BARBER-COLMAN COMPANY

Dept. W, 1823 Rock Street, Rockford, Illinois

No. 125 on Reader Service Card

*Propulsion and Accessory Equipment*

**FACILITY** — A capability brochure published by **Pioneer Tool & Engineering Co., Dept. S/A, 7401 W. Lawrence Ave., Chicago 31, Ill.**, outlines the firm's equipment, research, development, and engineering facilities. The company is concerned with components and assemblies for stable platforms, gyros and analog and digital computers.

No. 338 on Reader Service Card

**CONNECTOR** — A quick reference product bulletin giving complete information including termination and assembly procedures for MIL-C-26500 is offered by **The Pyle-National Co., Dept. S/A, 1334 No. Kostner Ave., Chicago 51, Ill.** The bulletin outlines construction features, insert arrangements and dimensional data.

No. 339 on Reader Service Card

**SWITCHES**—A 4-page folder entitled "Precision Switches For High Temperature Locations" has been released by **Micro Switch, Dept. S/A, Freeport, Ill.** It briefly describes several of many switch types that provide dependable precision snap-action switching in both high and low temperature extremes.

No. 340 on Reader Service Card

**TEMPERATURE REGULATOR** — An eight-page temperature regulator catalog, TCV-1, is now available from **OPW-Jordan, Dept. S/A, 6013 Wiehe Rd., Cincinnati 13, Ohio.** The catalog is fully illustrated and contains complete engineering information and technical rata on ¼ to 6-inch size units.

No. 341 on Reader Service Card

**SNUBBERS**—A 4-page folder entitled "Chemiquip Industrial Porous Metal Pressure Snubbers" illustrates and describes a line of pressure snubbers available from **Chemiquip Co., Dept. S/A, 36 E. 10 St., New York 3, N. Y.** It shows several representative devices, and provides general technical data.

No. 342 on Reader Service Card

**PIEZOELECTRICITY**—A 16-page illustrated booklet on the application of piezoelectric devices that highlights new developments in high-power handling abilities of the materials is available from **Clevite Electronic Components, Dept. S/A, Bedford, Ohio.** The booklet shows principal uses of piezoelectricity, outlines and compares the performance characteristics of all major piezoelectric substances.

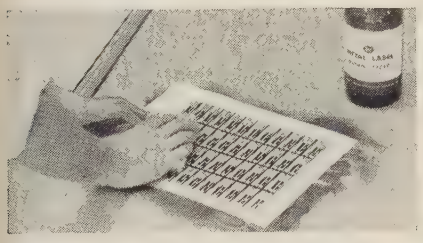
No. 343 on Reader Service Card

# 3M Materials Memo

News of materials for the aerospace industry – selected from the 27,000 products of the 3M Company

## A SIGN OF THE TIMES

In this troubled old world full of bad omens and forebodings of doom, a good sign is a mighty welcome thing. Even when that sign is only an aluminum emblem or identification plate, it's gratifying to know that it can be made – and will perform without causing you grief. In fact, we'll go a step further to say that making and using sign plates from our "Scotchcal" Brand Photosensitive Metal Label is a real breeze. With it, you can literally bring the metal label making capability in-house, where you've got full control. No more delays or premium charges because yours is a low quantity order. Best of all, you can have this capability without investing in a raft of special equipment.



Here's how it works. Using conventional photo-copy techniques, you make a positive or negative film from your original art. (Even without a camera, you can still make direct or reverse copy films from your original with "Scotchcal" Brand Photosensitive Exposure Film by direct contact printing.) From here on, it's just a simple contact printing routine on the metal label using most any ultra-violet emitting light source. Development is merely a matter of swabbing the label surface with a single solution. What's more, no darkroom is needed. "Scotchcal" Brand Metal Label can be safely handled in subdued light.

To apply the finished label to a clean dry surface, you strip the protective liner from the back of the adhesive, press it in place and that's it. The result is an aluminum label that's durable and weather resistant. It's high in fade resistance and stands up well to gasoline, oil and other hydrocarbons as well. Sign up for the full story.

## UNSTABLE DIMENSIONS YOUR PROBLEM?

When those dimensions are personal ones like the distance around the midriff, there's cause for irritation—but certainly not alarm. A generous portion of will (or won't) power will usually bring things back in line. But in precision templates, patterns or even chart grids, dimensional variance can easily scuttle the whole operation. Here the answer lies not in control, but in picking the proper stock material in the first place.

**PHYSICAL PROPERTIES OF TEN MIL FILM**
**TENSILE AND ELONGATION**

| | |
|---|---|
| **Lengthwise Direction** | |
| Yield point (lb./inch width) | 129 |
| Elongation at yield point % | 4.0 |
| Break point (lb./inch width) | 208 |
| Elongation at break point % | 110.2 |
| **Crosswise Direction** | |
| Yield point (lb./inch width) | 158.5 |
| Elongation at yield point % | 4.3 |
| Break point (lb./inch width) | 200 |
| Elongation at break point % | 160 |
| **MULLEN BURST TEST** | |
| Pounds per square inch | 445 |

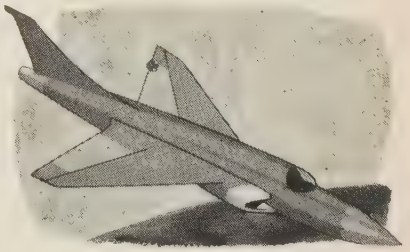
Where precise printed impressions are concerned, it's pretty hard to beat our PRINTING PRODUCTS DIVISION's "Scotchprint" Brand film. Made in calipers ranging from 2-10 mils, it's in a class of its own in dimensional stability. The change in any direction is less than $2.0 \times 10^{-5}$ inches/inch for each °F or each % change in relative humidity. Printability too is top notch – either on "Scotchprint" in an opaque paper-like form or as a translucent material. What's more, these impressions can vary all the way from delicate lines to half tones and solids. Like to see "Scotchprint" with a light sensitive coating – or a pressure sensitive adhesive? It's no problem.

"Scotchprint" film is a rugged performer too in quite a few ways. As a 10 mil film, it has a break point of 208 lbs./in. width. It resists even boiling water, mildew, oil, many solvents and chemicals—and repeated creasing won't crack it. Check the coupon below to learn how "Scotchprint" can keep your problem in its proper proportions.

## TO BOND OR NOT TO BOND?

"To be or not to be, that is the question." In Shakespeare's day, they rattled swords. Today they rattle missiles. Now the question becomes, "To bond or not to bond?"

"Reduce the weight and increase the strength" is the "hue and cry" in both aircraft and missile design. This means thin, strong, and often stressed skins subjected to maximum loads and extreme fatigue. Traditional methods of metal joining just won't meet the need. So – it's research to the rescue with the chemical bond.



A new technical brochure, available from our ADHESIVES, COATINGS & SEALERS DIVISION, presents the principles of structural bonding. It points out that mechanical fasteners (bolts, rivets, etc.) require holes which weaken skins and result in stress concentrations. Welding and brazing can ruin heat treatments or distort parts. Conversely, structural adhesives distribute loads evenly over joint areas, seal as they join, and open new horizons of fatigue resistance. As an added bonus, the 12 page brochure contains a packet of data sheets on the 3M structural adhesives that helped change the old art of adhesive bonding to the new tool of the structural engineer.

If you would like a copy of this "Scotchweld" Brand Structural Adhesive brochure, check the box below or ask for one from your local ADHESIVES, COATINGS & SEALERS DIVISION representative.

Missile Industry Liaison – Dept. VAA-111
Minnesota Mining & Manufacturing Company, St. Paul 6, Minn.
Please send more information on:

☐ "Scotchcal" Brand Photosensitive Metal Label ☐ "Scotchprint" Brand Film
☐ "Scotchweld" Brand Structural Adhesive
☐ Start sending me your bi-monthly "Materials Memo" Bulletin

NAME_____

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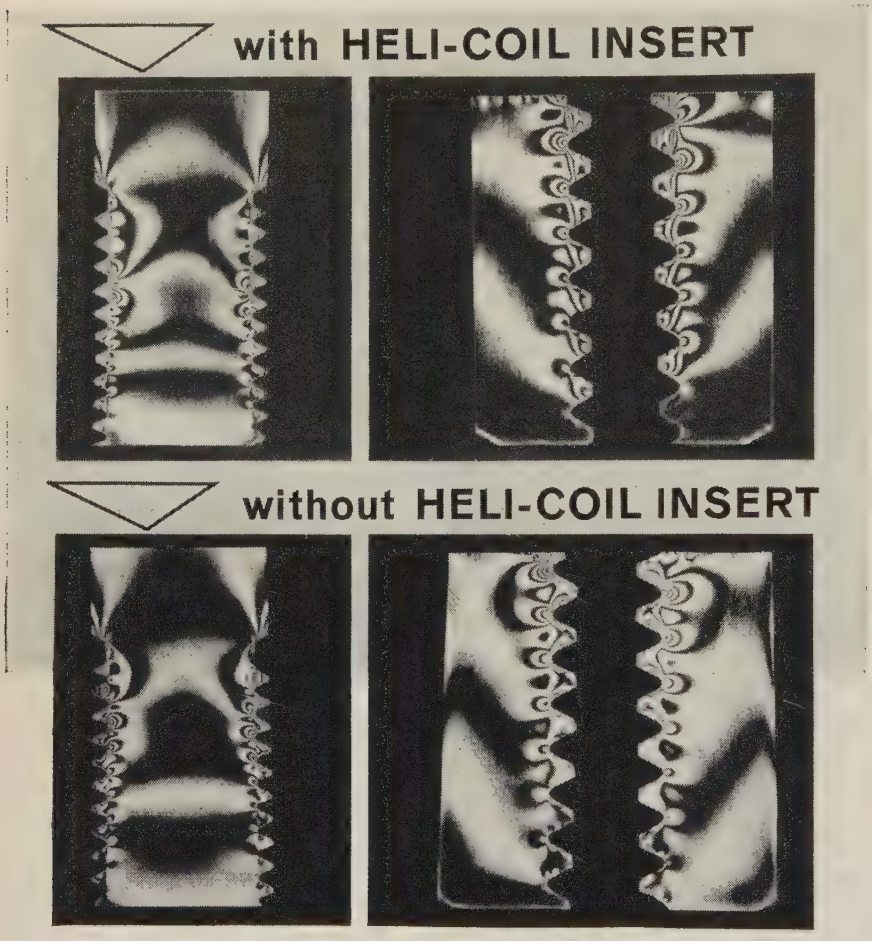
"SCOTCHCAL", "SCOTCHWELD", AND "3M" ARE REGISTERED TRADEMARKS OF 3M CO., ST. PAUL 6, MINN.

**Missile Industry Liaison** 3M COMPANY

No. 264 on Reader Service Card for Brand Film
No. 126 on Reader Service Card For Metal Label
No. 265 on Reader Service Card for Structural Adhesive

# How HELI-COIL® Stainless Steel Wire Inserts Eliminate Stress Concentration and Insure Maximum Strength in Threaded Assemblies




Made of stainless steel wire, precision-rolled to a diamond-shaped cross-section, ***Heli-Coil*** screw thread Inserts provide two exclusive characteristics directly related to threaded assembly strength:

**1. Permanent, *resilient* threads between the threads of the male and female assembly members.** These eliminate stress concentrations (upper photos) by distributing the load evenly along the full length of thread engagement in both members. By contrast, note the sharp stress concentrations (lower photos) around the first two threads of the conventional assembly.

NOTE: Diagrams at right show how ***Heli-Coil*** Inserts compensate for lead and angle error between female and male threads.

**2. A superior surface finish (8-15 RMS).** This holds friction loss to a minimum and, thus, provides maximum, consistent clamping load at any given wrench torque load.

**RESULT:** No stress concentration; improved fatigue strength in the male member; and a stronger assembly under all conditions.

●

There is a complete line of ***Heli-Coil*** products for every thread need: inserts, taps, tools and gages. Let us help with your design and application problems. Write today for complete information. 3146

**HELI-COIL CORPORATION**
111 Shelter Rock Lane, Danbury, Conn.

In Canada: ARMSTRONG BEVERLEY ENGINEERING LTD., 6975 Jeanne Mance St., Montreal 15, Que.




**FACILITY**—An eight-page brochure describing its engineering, management consultant, and publications engineering capabilities is available from **Industrial Technological Associates, Inc., Dept. S/A, 2108 Payne Ave., Cleveland 14, Ohio.** The brochure describes government programs engaged in by the company, as well as specific functions of the various divisions.

No. 344 on Reader Service Card

**O-SEALS**—Two complete lines of O-seal valves and fittings for liquid or gas service are described in Catalog 60-B released by **Combination Pump Valve Co., Dept. S/A, 848 Preston St., Philadelphia 4, Pa.** The catalog describes a unique soft-seated valve closure principle which assures positive valve shut-off at pressures to 6000 psi.

No. 345 on Reader Service Card

**PUMPS**—A four-page, two-color bulletin describing a complete line of seal-less leakproof pumps is available from **Chem-pump Div., Fostoria Corp., Dept. S/A, Huntingdon Valley, Pa.** The bulletin discusses design, operation and selection of canned pumps.

No. 346 on Reader Service Card

**TEFLON-LINED HOSE**—Bulletin No. 5, published by **Timely Technical Products, Inc., Dept. S/A, 100 Pine St., Verona, N. J.,** describes their line of Teflon-lined bronze and stainless industrial hoses. As described, the hoses are manufactured from a special inner core of 100 percent virgin TFE 6 Teflon, and extended to exact dimensions. Special braiding equipment applies the tightly woven stainless or bronze overbraiding.

No. 347 on Reader Service Card

**SERVOMOTOR**—A data sheet fully describing a Size 5 motor-generator, Model 9005-1102-0, has been published by **Beckman Instruments, Inc., Dept. S/A, 2500 Fullerton Rd., Fullerton, Calif.** Standard electrical specifications are fully delineated, as well as motor dynamics and generator output performance.

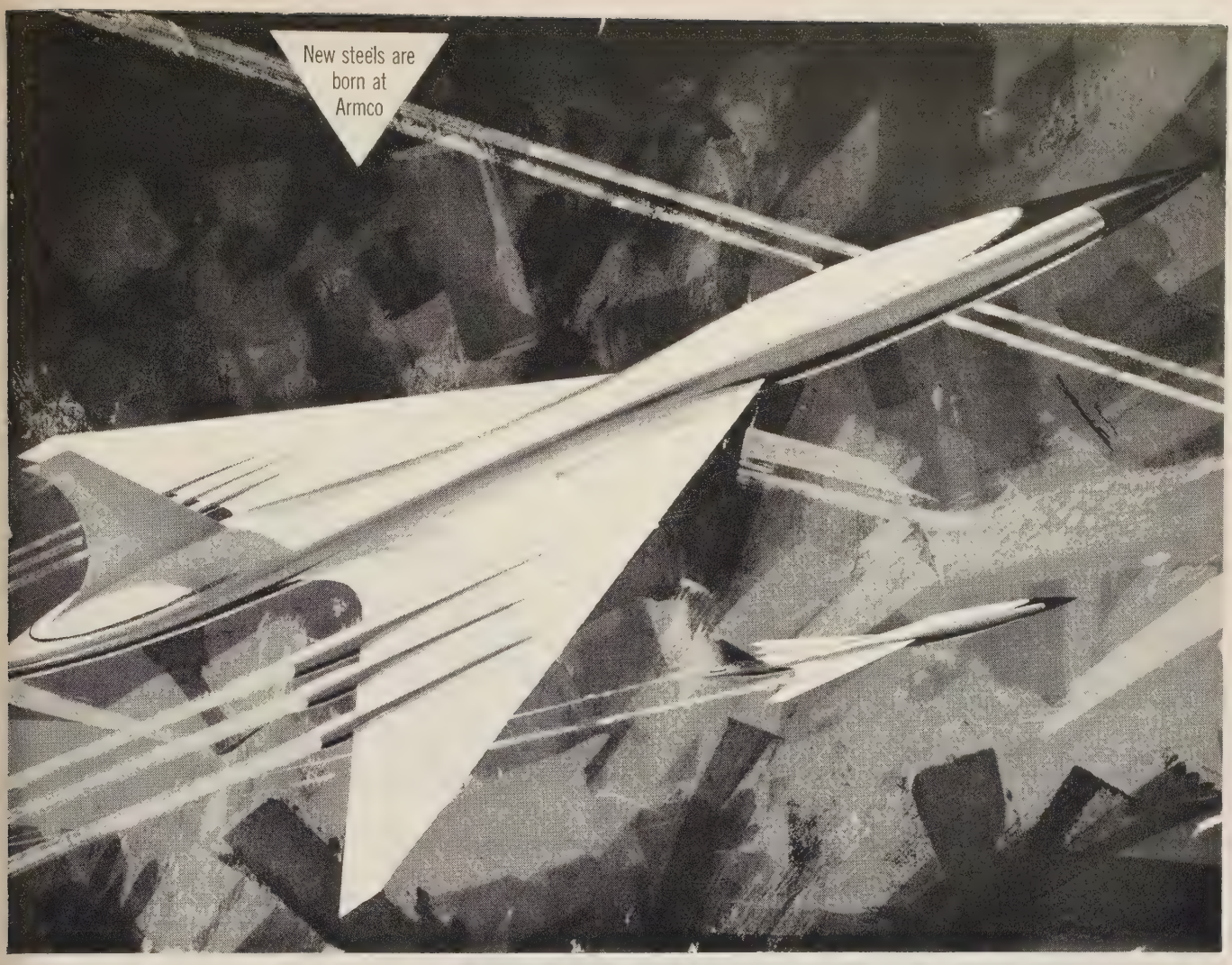
No. 348 on Reader Service Card

**LIQUID SPRINGS**—A line of liquid dashpots, springs, and shock absorbers for energies to 460,000 ft-lb are covered in a 12-page handbook from **Taylor Devices, Inc., Dept. S/A, Tonawanda, New York.** Principles of operation, construction features and specifications of standard units are featured.

No. 349 on Reader Service Card



No. 127 on Reader Service Card




# Armco PH 15-7 Mo Stainless Steel Helps Clear Way for Mach 3 Transports

Many of the formidable barriers to production of Mach 3 jet transports are eliminated by Armco's Precipitation-Hardening Stainless Steel—PH 15-7 Mo.

It combines the necessary characteristics for such critical use—high strength-weight ratios, useful high temperature properties, good corrosion resistance, producibility and economy.

Extensive use of Armco PH 15-7 Mo in the B-70 has led to development of cost-cutting techniques for production of PH 15-7 Mo parts. In addition, valuable data on critical properties have been accumulated. Produced in practically all commercial forms—foil, sheets, strip, plate, bars, wire, extrusions and forging billets, Armco PH 15-7 Mo is used in airframe, powerplant and accessories.

Stainless Steel

For Light-Weight Strength, Durability and Economy.

Let us send you useful data on the properties and fabrication of this special Armco Stainless Steel.

**Armco Division, Armco Steel Corporation, 2601 Curtis St., Middletown, Ohio.**

ARMCO

## Armco Division

No. 128 on Reader Service Card

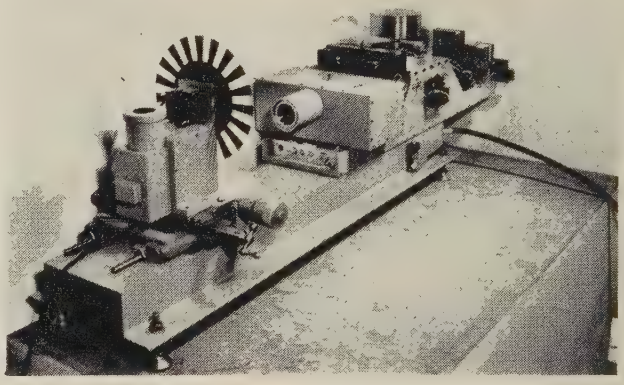
# DESIGN DEVELOPMENTS

*For more details on the equipment, processes and facilities described in this section,*

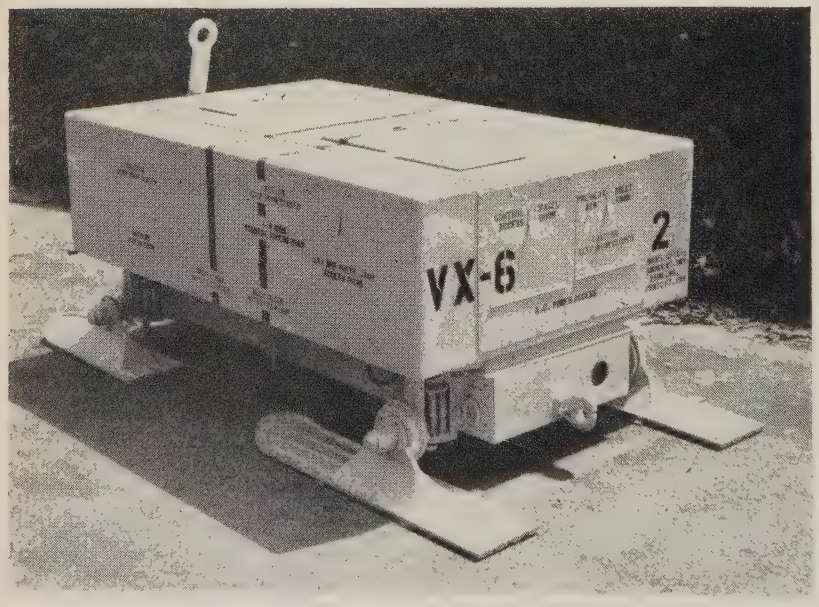
## FRICTION-FREE INERTIAL TRACKER ACCURATE AT TRACKING NULL

Accuracies of close to five feet at 2000 miles are claimed for its new tracker by Radio Corp. of America, Aerospace Communications & Controls Div., Burlington, Mass. Approaching tracking null lost, previous trackers always lost accuracy because of the inherent friction of supporting gear and servo mechanisms, RCA explains. The tracker rests on an air bearing and has a rotating flywheel, and therefore is friction-free. The flywheel, rather than the tracker support, absorbs the momentum of the moving tracker.

All mechanical energy interchange is contained within the tracker mass itself. As the tracker approaches null and loses speed, the slight viscous-drag of the air bearing disappears.



## Checkout and Starter Sled for -100 deg F




This ground power sled will be used by the Navy to eliminate many of the support problems of jet aircraft pre-flight and start in subarctic weather. Of five units being manufactured by the Garrett Corp., AiResearch Manufacturing Div., 9851 Sepulveda Blvd., Los Angeles 45, Calif., one has already been delivered to the Navy's Antarctic Air Development Squadron.

Operating in —100 deg F weather, the sled can generate AC and DC power for engine checkout as well as pneumatic power for starting. Its powerplant is AiResearch's GTCP-100-1 gas turbine, which produces a minimum of 120 lb of pneumatic power, 400-cycle AC power, and 28-V DC power.

## Vacuum Gages for Very Low Gas Pressures

Two ionization-type vacuum gages for measuring extremely low gas pressures are available from the Westinghouse Electric Corp., Electronic Tube Div., Box 284, Elmira, N. Y. Because of their wide, overlapping ranges, they are claimed to be the first such gages that can be paired to take measurements over a continuous range from $10^{-10}$ to $5\times10^{-1}$ mm of mercury.

The WL 7903 covers the "high pressure" end of the range, from $10^{-5}$ to $5\times10^{-1}$ mm; at the low end, the WL 7904 measures from $10^{-10}$ to $10^{-3}$ mm.

Externally identical, both gages are normally packaged as cylindrical glass envelopes, 2¾ in. long and one inch in diameter, fitted with a standard eight-pin Jetec E8-11 tube base. Envelopes can also be made of Pyrex, Nonex, and Kovar sealing glass in diameters up to one inch. Normal air cooling provides adequate heat dissipation.

The gages have three electrodes—a heated cathode, a positively charged electron collector, and a negatively charged ion col-

# Testing and Support

*write in item numbers on Reader Service Card*

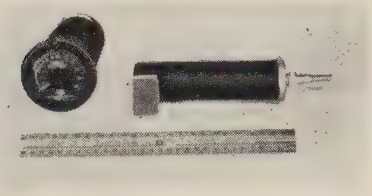
lector. In use, these elements are surrounded by gas from the system under study.

Bombarded by electrons streaming from the cathode to the electron collector, gas molecules from the system are ionized positively and attracted to the negatively charged ion collector to produce a direct current in an external circuit. When this current is matched against current flowing in the grid circuit, the ratio is directly proportional to the pressure in the closed system. When amplified, the ratio-signal is used to drive indicating, switching, and recording devices.

The WL 7903 has a thoria-coated iridium filament, for measurement in high-oxygen atmospheres, that provides protection against burnout if normal atmospheres enter the gage. Operating filament voltage is 1.3 V; filament current is 2.4 amp (at $10^{-5}$ mm); ion collecter voltage is +60 V. For outgassing (purging the metal parts of residual gases), the tungsten electron collector is used as an electron emitter to initiate a 13-amp current through the gage.

In the WL 7904, three separate tungstem filaments can be connected in any series-parallel combination to afford spares, if desired. Although maximum operating values are higher, recommended values are for a filament voltage of 4 V, AC or DC; filament current of 4 amp; ion collector voltage of —30 V; and electron collector voltage of 150 V. For outgassing, the grid and ion collector are used as a 500-V plate and filament voltage is raised to produce a high emission current. **60**

## Noise Used as Measure of Jet Thrust



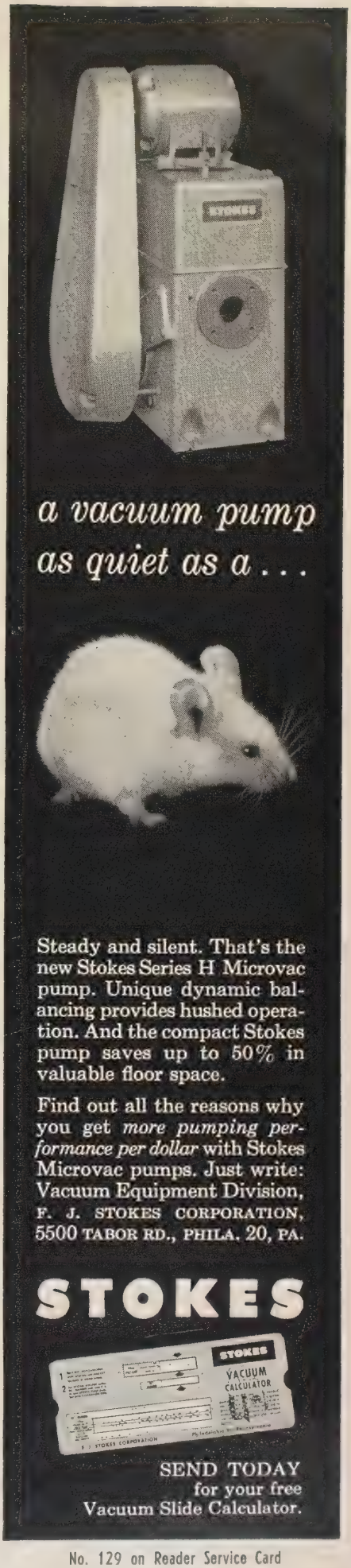
A simple, two-component device for measuring the thrust of jet engines has been introduced by Industrial Acoustics Company, New York 54, N. Y. It is based solely on the correlation between a jet engine's exhaust noise output and thrust.

By first filtering the sound to a narrow spectrum and then comparing the intensity of that band with a previously calibrated scale, the indicator calculates within two per cent the engine pressure needed to produce such noise intensity.

The "sonic sensor" is directional, so that there is no interference from other engines. It may be mounted inside the aircraft, since it requires no outside opening. The "sound integrator" component, which houses the readout meter, is independently located for convenience of reading. **61**

**DEAD WEIGHT GAGE** — A dead weight gage, designed as a master pressure standard for the generation and measurement of pressures to 40,000 psi, has been developed by **Ruska Instrument Corp., Dept. S/A, 6121 Hillcroft Ave., Houston 36, Tex.** Designated the Model 2450, the new unit features nonmagnetic stainless steel weights, and is calibrated to within 0.002 per cent of Class "S" standard masses. Pressure is measured from 60 to 40,000 psi in 1 psi increments. Accuracy of the unit is 0.01 per cent of reading. Resolution is 0.005 per cent or better.

No. 350 on Reader Service Card



a vacuum pump
as quiet as a . . .
Steady and silent. That's the new Stokes Series H Microvac pump. Unique dynamic balancing provides hushed operation. And the compact Stokes pump saves up to 50% in valuable floor space.
Find out all the reasons why you get more pumping performance per dollar with Stokes Microvac pumps. Just write: Vacuum Equipment Division, F. J. STOKES CORPORATION, 5500 TABOR RD., PHILA. 20, PA.
STOKES
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SEND TODAY
for your free
Vacuum Slide Calculator.

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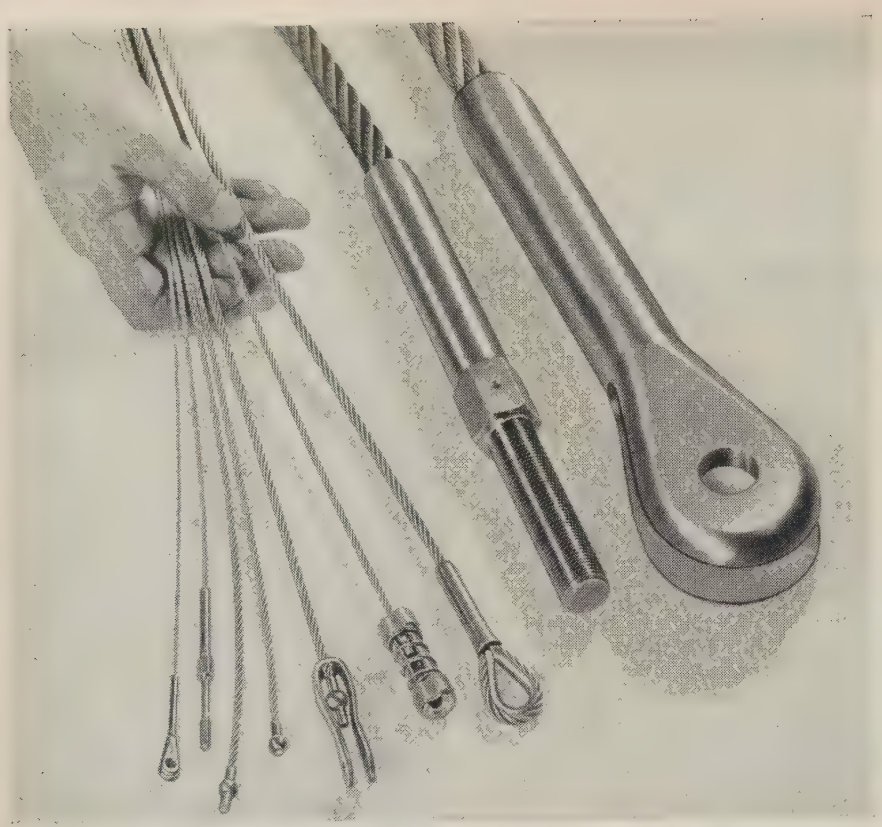

# Tru-Loc Swaged Aircraft Fittings

## guaranteed free from defects...

**Tru-Loc aircraft fittings** are guaranteed three ways—they conform to specified dimensions; they hold to the minimum rated breaking strengths of the cables to which they are swaged; and they are free from deformation, splits and internal cracks. With Tru-Loc swaged fittings you also get:

**Widest range of sizes** • Tru-Loc fittings are available for cables ranging from 1/16" to 2½" diameters.

**Types for every application** • Sleeve-type, ball-type, ball-with-strap, center-pull loop fittings, "*Quickies*" for instant connect and disconnect—all of these fittings were originated by American Chain & Cable Company, Inc. Special fittings can be designed as required.

**"NO-MAG" CABLES GIVE BETTER CORROSION-RESISTANCE THAN STAINLESS STEEL** "No-Mag" cable is non-magnetic, won't interfere with instrument operation. In corrosion-resistance and thermal characteristics, it is superior to standard stainless steel. "No-Mag" aircraft cables also offer high fatigue and abrasion resistance, are available in a complete range of sizes in all the standard aircraft constructions.

***GET THE COMPLETE STORY*** *on ACCO products for the aircraft industry*
*Write to the Detroit Office*

ACCO **TRU-LOC FITTINGS**

TRADE MARK

**Automotive and Aircraft Division**
**American Chain & Cable Company, Inc.**

601-T Stephenson Bldg., Detroit 2
6800-T East Acco St., Los Angeles 22 • 929-T Connecticut Ave., Bridgeport 2 Conn.


**COATING TESTER**—A non-destructive testing device has been developed by **Twin City Testing Corp., Dept. S/A, 533 So. Niagara St., Tonowanda, N. Y.**, for accurate gaging of non-conductive coatings on aluminum and its alloys. In addition to gaging non-conductive coatings on non-ferrous base metals, the Type EC Permascope offers a non-destructive means of measuring the thickness of a non-ferrous metal on a non-ferrous base. A compact, portable unit measuring 9 x 6½ x 6½ in., the Permascope operates on 110 volts a-c.

No. 351 on Reader Service Card

**GSE BENCH**—A bench to accommodate a full range of GSE for squadron level maintenance and depot overhaul is available from **Zero Manufacturing Co., Dept. S/A, 1121 Chestnut St., Burbank, Calif.** Panels are marine plywood bonded on each side by 0.016 in. aluminum skins. Elimination of conventional riveting permits the benches to meet all requirements of MIL-M-8090-C and MIL-W-8421.

No. 352 on Reader Service Card

**CONTINUITY CHECKER**—A tester, hand-portable and battery powered, is used to test exploding bridgewires and provide positive indication of wire and circuit continuity in EBW igniters, pressure cartridges and explosive bolts. Until the development of the checkout unit, according to **Special Devices, Inc., Dept. S/A, 16830 W. Placerita Canyon Rd., Newhall, Calif.**, no safe and positive determination of bridgewire reliability could be made.

No. 353 on Reader Service Card

**MOBILE CLEAN ROOM** — This packaged mobile clean room is complete with air conditioning, filtration system, air shower, lighting, toilet facilities, dressing room, interlock, and electric outlets. The entire unit is factory manufactured by **Clean Room Div., Controlled Atmosphere Enclosures Mfg. Co., Dept. S/A, P. O. Box 5864, Jacksonville 7, Fla.**, and can be delivered ready for use.

No. 354 on Reader Service Card

**SWITCH** — An adjustable accelerometer switch, for use in preliminary testing where actual accelerations are not known, has been developed by **Humphrey, Inc., Dept. S/A, 2805 Canon St., San Diego 6, Calif.** The unit may be adjusted on a centrifuge or rate table. This instrument features air damping and flexure suspension. Hermetically sealed units are also available for unlimited altitude use.

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No. 130 on Reader Service Card

No. 166 on Reader Service Card

# At Lamb Electric...Engineers with FHP motor "know-how" solve intricate design problems

At Lamb,® every fractional horsepower motor design problem is special. Because the problems are special, Lamb engineers funnel their years of "know-how" into each intricate project. The result: unusual benefits for you.

Fractional horsepower motors from Lamb incorporate the best possible design, flexibility, and production economy.

If you have a special motor problem . . . here's what you can expect from Lamb. Into the design goes years of experience in power components for aircraft, domestic and industrial products. Out of the design comes a personalized motor that's dependable, smooth and efficient.

Cost-wise, you're way ahead, because Lamb Motors are mass-produced at the most favorable cost.

Write today for descriptive folder. Or ask to have a District Engineer call and set up a personalized "Motor Conference".

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A Division of American Machine and Metals, Inc.
In Canada: Lamb Electric—Division of Sangamo Company, Ltd.
Leaside, Ontario

*Lamb Electric*
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

***Divisions of American Machine and Metals, Inc., New York 7, New York*** TROY LAUNDRY MACHINERY
RIEHLE TESTING MACHINES • DE BOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS
NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC CO. • HUNTER SPRING CO. • GLASER-STEERS CORP.

# AVDEL

POSITIVE LOCKING • QUICK RELEASE

## BALL-LOK® PINS

to SECURE IT...
to RELEASE IT *Instantly!*

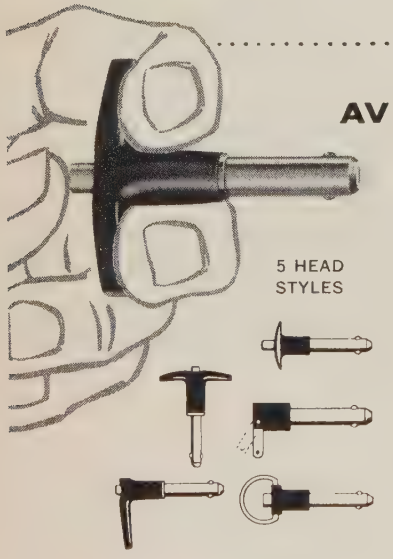
*Available for Immediate Delivery*

### AVDEL DOUBLE ACTING

3 HEAD STYLES



Avdel Double Acting positive-locking pins are best for joining mechanical units requiring rugged, sure-safe fastening . . . yet easy and quick assembly and disassembly. No nuts or cotter keys to bother with . . . simply insert the pin and it holds securely 'til released. Push-pull in operation, pin cannot be removed until release button is pushed or handle is pulled. Tapered end makes insertion easy. Optional Knock-out type plunger is available. Three head styles are available from stock in alloy steel and stainless steel with a wide variety of diameters and grip lengths.
Manufactured to NAS Standards.



### AVDEL SINGLE ACTING

*Available for Immediate Delivery*

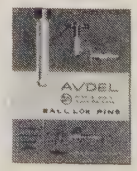
5 HEAD STYLES

Avdel Single Acting pins provide positive safety with easy insertion for quick assembly . . . and instant release when the Ball-Lok button is manually depressed. No nuts or cotter keys to bother with . . . simply insert the Avdel pin, release the button, the pin holds securely until you release it. The ideal fastener for blind or difficult access areas. Five head styles are available for use in various types of applications.
Available from stock in both alloy steel and stainless steel in a wide range of diameters and grip lengths. Manufactured to NAS Standards.

### AVDEL SPECIAL PINS

Avdel has engineered over 3,000 special pins to specification for exotic applications from ¼" to 3" diameters, up to 14 feet in grip length. Unusual release methods may be employed such as solenoid, hydraulic, lanyard and others. This engineering experience is available to you to help pre-solve your fastener problems.

*Write for brochure showing how to use Avdel Ball-Lok Pins*




AVDEL INC.
210 So. VICTORY BLVD., BURBANK, CALIF.
TORONTO, CANADA • HERTS, ENGLAND • GENEVA, SWITZERLAND

No. 131 on Reader Service Card




**VACUUM THERMOCOUPLES** — The availability of a complete range of miniature vacuum thermocouples, including a new design, has been announced by **Barker Sales Co., Dept. S/A, 339 Broad Ave., Ridgefield, N. J.** The range of the thermocouples includes types for low and audio frequencies with heater ratings from 1.25 ma and up and UHF types have straight through heaters and low inter capacity. Types with zero reversal error are offered.

No. 356 on Reader Service Card

**IR DETECTOR** — An infrared-detecting production test unit, fully-automatic, is a comprehensive measurement console to be used in space and satellite programs. The instrumentation package is designed for rapid, large-volume production testing of multi-element infrared-sensitive photoconductor arrays, says **Aerojet-General Corp., Dept. S/A, Azusa, Calif.** It records signal, noise, noise-to-signal ratio, cell current and cell voltage.

No. 357 on Reader Service Card

**LOX CYLINDER** — A liquid oxygen cylinder with a capacity of 3000 cu. ft is now available from **Linde Co., Dept. S/A, 270 Park Ave., New York 17, N. Y.** This large capacity LC-3 cylinder weighs only 463 lb and requires only ⅓ the storage space of equivalent high pressure cylinders. The cylinder delivers 300 cu ft of oxygen per hour at pressures up to 75 psi. It meets all ICC safety specifications.

No. 358 on Reader Service Card

## DATA FILE

**TRANSDUCERS**—Product Note 3010, four pages, covering weld-on surface temperature transducers, has been issued by **Trans-Sonics, Inc., Dept. S/A, P.O. Box 328, Lexington 73, Mass.** Outline drawings ond specifications for 12 models are included in the bulletin.

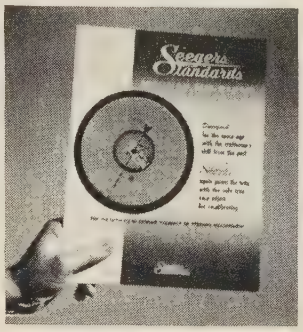
No. 359 on Reader Service Card

**PROPELLANT LOADING**—A four-page brochure describing system control of propellant loading is available from **Trans-Sonics, Inc., Dept. S/A, P.O. Box 328, Lexington, Mass.** The brochure details principles of operation, calibration, and summarizes specifications.

No. 360 on Reader Service Card

## *Need extreme accuracy in pressure measurements?*

This booklet gives full information on Seegers precision test gauges. They can be recalibrated to 0.10% FS accuracy with a screwdriver




All extremely accurate precision test gauges eventually lose some degree of calibration accuracy as a result of bourdon tube fatigue. But only Seegers offers a *true* recalibration capability through an exclusive Zero Reference Adjust feature. It lets you recalibrate Seegers test gauges in the field to their original accuracy of 0.10% FS over their *entire pressure range,* with a simple screwdriver adjustment. No special tools or testing equipment is required.

Seegers gauges are available in ranges from 0-15 to 0-10,000 psig. They feature Ni-Span C and stainless steel components, eye-ease green dial with white increments linear to ±.001", and bourdon bleed and flush valve as standard equipment. Write for booklet containing technical information and data on exclusive recalibration feature, calibration, accuracy, components, and prices.

**Seegers Instrument Company**

515 West Main Street, Barrington, Illinois

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871A

*Improved* **FEL-PRO C5-A** "HI-TEMP" ANTI-SEIZE THREAD COMPOUND

**delivers *MORE* dollar value at same LOW COST!**

**All These New Improvements—**

***NEW*** • Lower breaking and running torque

***NEW*** • Non-settling, non-hardening, homogenized composition

***NEW*** • Can be used in below freezing weather

***NEW*** • Increased lubricating and sealing qualities

***NEW*** • Prevents rust and corrosion

***Now in tubes and cans***

**FREE TEST SAMPLE PROVES HOW!**

You'll save countless man hours and avoid costly replacement of broken studs, bolts, etc., with the protective cushioning action provided by the colloidal copper composition of C5-A. Improved C5-A Lubricates and Seals for fast, easy application and removal. Gives same protective performance even after high-pressure, high-temperature use, up to 1800° F. Can be used on all metals and plastics.

- ✓ Ends seizing and galling even up to 1800° F.
- ✓ Reduces wrench torque
- ✓ Stops needless stud breakage
- ✓ Permits repeated re-use
- ✓ Speeds assembly and disassembly
- ✓ Prevents galling of stainless steel

***TRY C5-A NOW . . .***

*You'll find it ideal for aircraft uses such as slip joints, manifold studs, turbo blowers, etc. Write for your free test sample today!*

**FELT PRODUCTS MFG. CO.**

Dept. 52, 7450 N. McCormick Blvd., Skokie, Illinois

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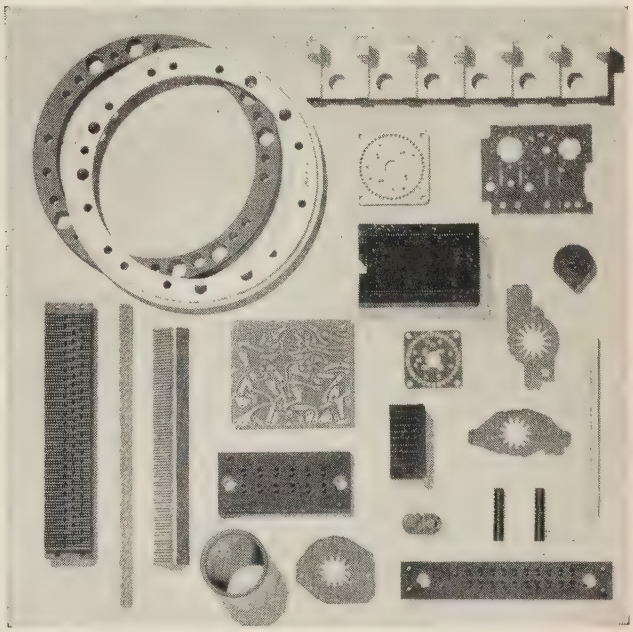
# RELIABLE Laminated Plastics for Electrical & Electronic Parts



**An Example of**

## Synthane *You-shaped* Versatility

Here, from one reliable source, you can satisfy all your requirements for laminated plastic materials or fabricated parts. High temperature laminates, flame-retardant laminates, copper-clad laminates as well as all the widely-accepted electrical grades. Complete facilities for quality-controlling desired properties and for environmental testing. For parts fabricated to your specifications we are equipped with a complete tool room for specialized dies and fixtures.

*You-shaped Versatility makes Synthane a Better Buy in Laminates.*

**SYNTHANE**

CORPORATION S OAKS, PENNA.

Synthane Corporation, 55 River Rd., Oaks, Pa.

Gentlemen:

Please send me information relating to Synthane as a source for laminated plastic materials and parts.

Name_____

Address_____

City_____ Zone____ State _____

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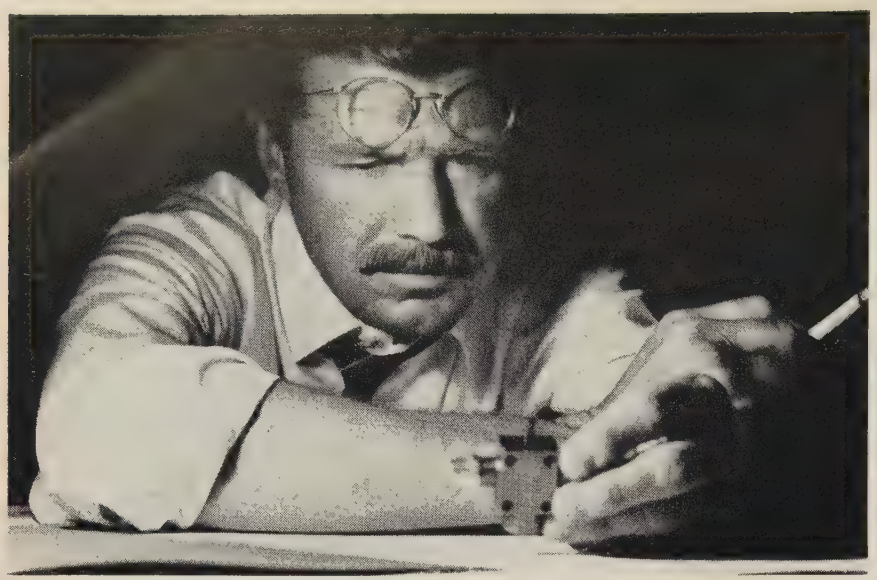

## MAJOR PROBLEM...in Propellant-Actuated Devices?

If your problem involves combining a sizeable force with light weight for positive, instantaneous operation, talk to the Pacific Division about propellant actuated devices. We have a wealth of experience in space vehicle applications, aircraft escape systems and ejectors for separation of airborne stores. Cartridge-actuated pin valves, pin pullers and other mechanisms can be used in many ways to accomplish a specific task. Our extensive facilities for engineering, manufacturing and testing are available. Call or write today.

PACIFIC DIVISION HOUSTON FEARLESS CORPORATION

*24660 Crenshaw Boulevard, Torrance, California / SPruce 5-1211*

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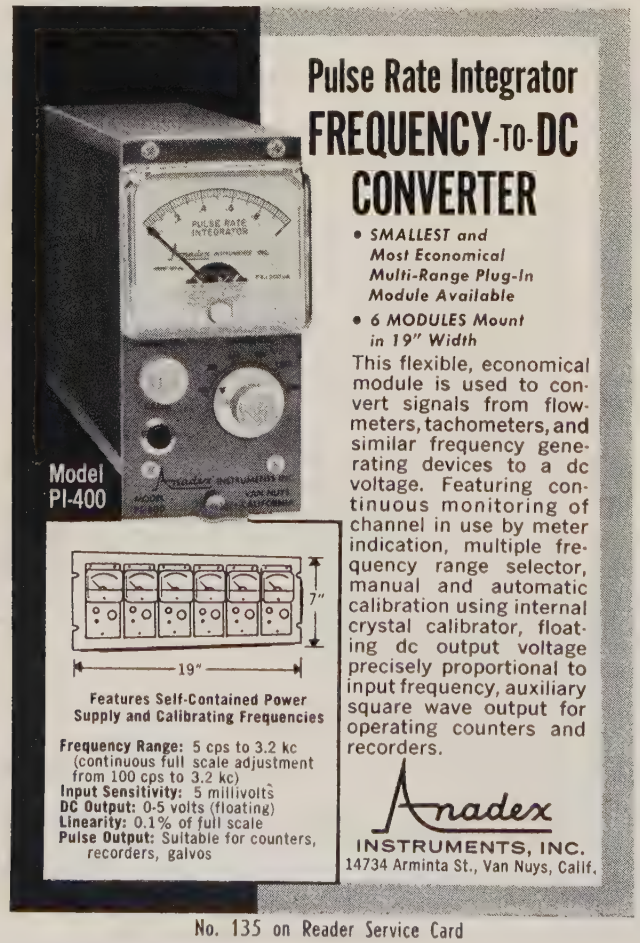

Pulse Rate Integrator
FREQUENCY-TO-DC
CONVERTER
• SMALLEST and Most Economical Multi-Range Plug-In Module Available
• 6 MODULES Mount in 19" Width
This flexible, economical module is used to convert signals from flowmeters, tachometers, and similar frequency generating devices to a dc voltage. Featuring continuous monitoring of channel in use by meter indication, multiple frequency range selector, manual and automatic calibration using internal crystal calibrator, floating dc output voltage precisely proportional to input frequency, auxiliary square wave output for operating counters and recorders.
Model PI-400
7"
19"
Features Self-Contained Power Supply and Calibrating Frequencies
Frequency Range: 5 cps to 3.2 kc (continuous full scale adjustment from 100 cps to 3.2 kc)
Input Sensitivity: 5 millivolts
DC Output: 0-5 volts (floating)
Linearity: 0.1% of full scale
Pulse Output: Suitable for counters, recorders, galvos
Anadex
INSTRUMENTS, INC.
14734 Arminta St., Van Nuys, Calif.

No. 135 on Reader Service Card

*Testing and Support*

**CLEANING**—A guidebook on chemical cleaning for missile propellant loading systems has been published by **Oakite Products, Inc., Dept. S/A, 152C Rector St., New York 6, N. Y.** This 4-page, illustrated booklet discusses the degree to which systems should be clean and the chemical preparation necessary to insure freedom from foreign matter.

No. 361 on Reader Service Card

**JACKS**—Leveling jacks for GSE use are shown in this 23-page catalog, published by **Saginaw Products Corp., Dept. S/A, 68 Williamson St., Saginaw, Mich.** A special section is given on actuator type ball screw jacks for missile launchers. Also included are military trailers, running gear, and casters.

No. 362 on Reader Service Card

**FACILITIES** — A booklet issued by **Monterey Research Laboratory, Inc., Dept. S/A, P. O. Box 1309, Monterey, Calif.,** describes their facilities and capabilities. In other literature, the company gives information on their impulsive method for programmed acceleration control — a shock test machine for precise shock testing. A third pamphlet covers compressible liquid springs and spring dampers.

No. 363 on Reader Service Card

**DYNAMOMETER**—Complete description and theory for the series A air dynamometer is given in a booklet issued by **Hydro-Mill Co., Dept. S/A, 1707 Cloverfield Blvd., Santa Monica, Calif.** It also includes dimension tables and drawings, a table of ranges, and a series of performance curves showing torque versus speed.

No. 364 on Reader Service Card

**TURNTABLES** — In Bulletin T900, **Dunn Engineering Corp., Dept. S/A, Cambridge, Mass.,** provides technical information on its air bearing turntable for gyro testing. In Bulletin T844, information is provided on a rate turntable designed for testing dynamic performance of rate gyros, accelerometers, and "g" switches.

No. 365 on Reader Service Card

**SENSORS**—This 4-page progress report on sensors has been released by **Designers for Industry, Inc., Dept. S/A, 4241 Fulton Parkway, Cleveland 9, Ohio.** case histories in the report show how sensing devices are used to inspect, control, measure, validate, and detect.

No. 366 on Reader Service Card

**THERMOCOUPLES**—A compilation of temperature conversion data on gold-cobalt vs copper thermocouples used in cryogenic application has been published by **Cryogenics, Inc., Dept. S/A, Stafford, Va.** The four-page folder covers the temperature conversion range from 0 to 300 deg K of gold +2.1 Atomic per cent cobalt vs copper thermocouples.

No. 367 on Reader Service Card

**TEST CHAMBERS**—Fourteen models of temperature-humidity chambers, ovens, and walk-in rooms and seven temperature test chambers are described in detail in a new bulletin issued by **Electric Hotpack Co., Inc., Dept. S/A, 8019A Cottman Ave., Philadelphia 35, Penna.** In addition to the standard models described, four pages cover special humidity cabinets, humidity ovens, and portable, automatic cycling temperature test chambers.

No. 368 on Reader Service Card

**HYDRAULIC SYSTEM** — Bulletin TD104, describing a six-channel hydraulic force control system, has been released by **Gilmore Industries, Inc., Dept. S/A, 13015 Woodland Ave., Cleveland 20, Ohio.** The system is designed for up to 100,000 lb force capacity per cylinder.

No. 369 on Reader Service Card

**LOAD CELLS**—A publication offering information on seven load cell models for measurement of tension and compression is available from **Microdot, Inc., Dept. S/A, 220 Pasadena Ave., South Pasadena, Calif.** Linearity and Hysteresis is within 0.2 per cent for the units, which are rated to 100,000 lb.

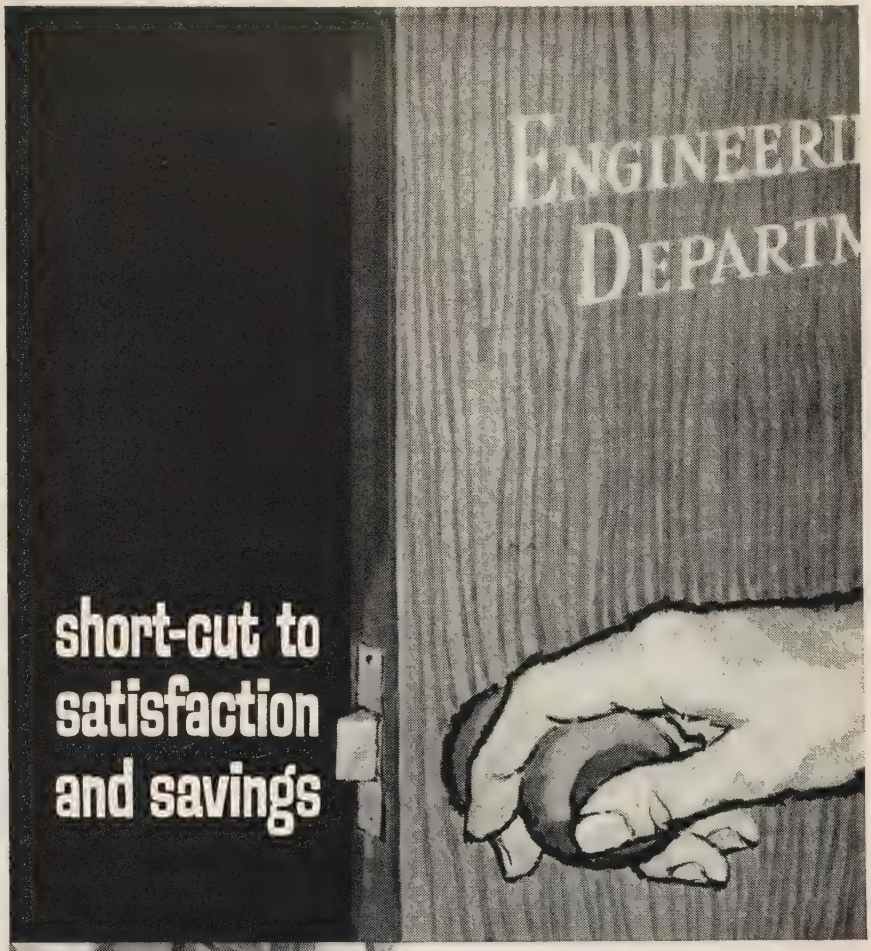
No. 370 on Reader Service Card

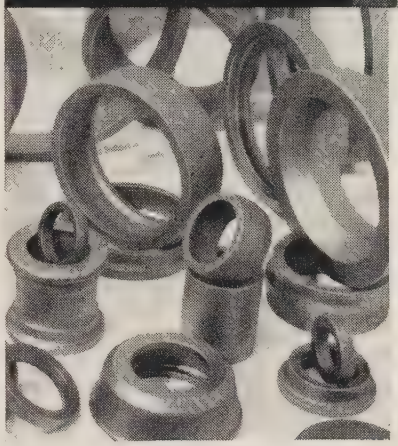
**TRANSDUCER**—A bulletin introducing a miniature airborne transducer for measurement of fluid and gas pressures is available from **Taber Instrument Corp., Dept. S/A, 107 Goundry St., North Tonawanda, N.Y.** Included are complete specifications, mounting data, sensitivity modifications prices, and ordering information.

No. 371 on Reader Service Card

**FILTERS**—A data sheet on Models 49S-T and 59S-L filters for cryogenic fluids, propellants, and high-pressure gases has been issued by **Dynatrol, Inc., Dept. S/A, 95 Liberty St., New York 6, N. Y.** The new data sheet includes engineering specifications, pressure ratings, temperature ranges, dimensional drawings, tabulations of flow rates and pressure drops, and a list of tested filterable materials.

No. 372 on Reader Service Card

Rolled Steel Rings of simple or complex cross-section can be produced by the Edgewater process, in diameters from 5 to 145 inches. Materials include carbon steel, stainless and heat-resisting alloys, tool steel.

Edgewater's first step in answering an inquiry for rolled steel rings is to have Engineering check the proposed design for possible modifications that would improve the ring and/or reduce the price. This assures a good design—one that meets all requirements, at lowest cost.

Forged from solid blocks of steel and rolled on a powerful ring mill, Edgewater weldless rings are formed to cross-section shapes so close to finished dimensions that very little machining is needed. Close tolerances mean less labor, less scrap loss, lower overall costs. The Edgewater rolling process assures maximum strength, toughness and uniformity. Send drawings for recommendations and prices.

INTERESTING description of the ring-rolling process is given in this brochure, **Edgewater Rolled Steel Rings.** We will be glad to send you a copy.

**Edgewater Steel Company**

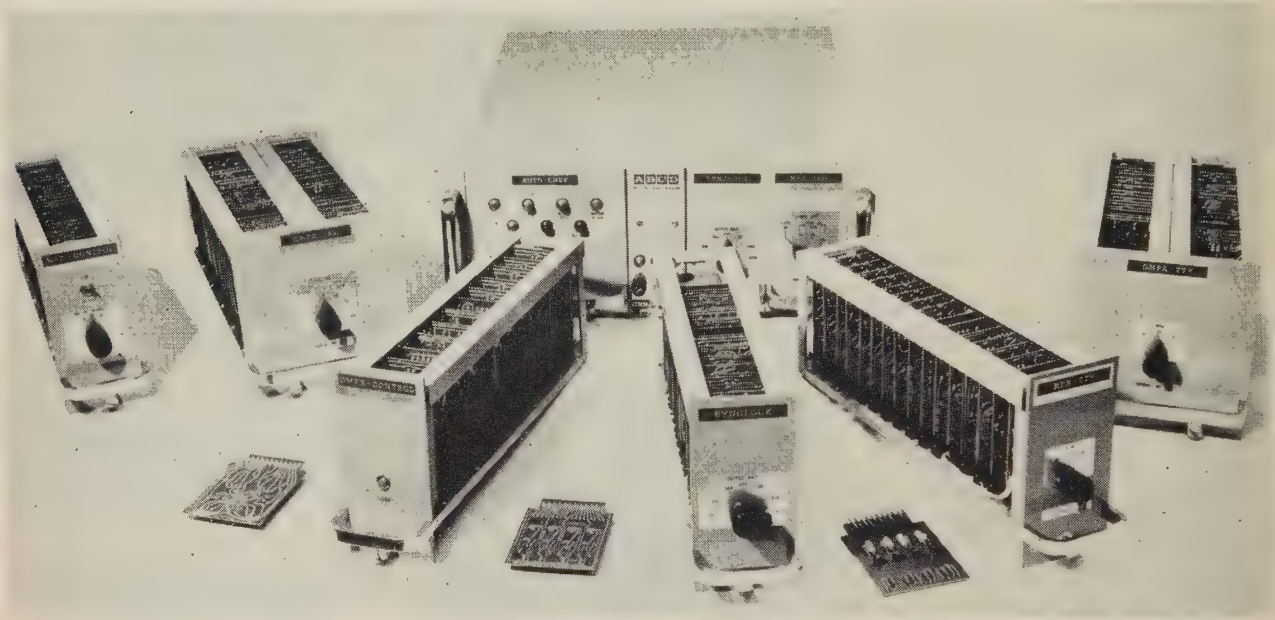
P.O. Box 478 • Pittsburgh 30, Penna.

No. 136 on Reader Service Card

# DESIGN DEVELOPMENTS

*For more details on the equipment, processes, and facilities described in this section,*

## BUILDING-BLOCK SYSTEM FOR MULTIPLE DATA TRANSMISSION



A flexible and expandable system of building-block communications devices for simultaneous high-speed transmission of digital information from a variety of sources has been developed by ACF Electronics Div., ACF Industries, Inc., Box 4, Riverdale, Md. The ABCD (*A*CF *b*uilding *b*lock *c*ommunications *d*evices) system was developed to fill the requirement for a single unit that can adapt information from computers and other data equipment for communication between remote locations.

According to ACF, this approach makes it possible for a military or industrial user to install only a single rack of interchangeable "plug-in" units to adapt all types of existing data equipment like teletypewriters, data transceivers, facsimile machines, and paper and magnetic tape machines for transmission of data over a standard telephone line. As many as 16 different machines may simultaneously feed their teletype, tape, punch-card, or other information into the ABCD, which will transmit the entire mass of information simultaneously at 4800 bits (or 600 characters) per second over a single line to the receiving point. There, another ABCD unscrambles the information and feeds it to teletype, tape, punch-card, or other machines, from which it emerges in its original form.

Each building block is designed for a specific function and made up of plug-in logic cards, which contain solid-state digital circuits. Typical functional units consist of multiplexers, demultiplexers, modulators, demodulators, serial-to-parallel and parallel-to-serial converters, an Auto-Check (a security device controller), and a Synclock (a stable clock and phase corrector). The fully transistorized, plug-in, printed-circuit construction reduces maintenance requirements to a minimum, ensures a maximum equipment availablity, and provides high reliability, it is claimed. **71**

## C-Band Radar Transponder Functions as Tracking Aid

The Model S-C 702 C-band radar transponder has been announced by Military Products Div., General Dynamics / Electronics, 100 Carlson, Rochester 3, New York. Designed as a tracking aid in missile and aircraft applications, it operates in C-band (5400-5900 mc) and responds to a coded interrogation from a tracking radar such as the AN/FPS-16 or AN/-MPS-26.

The unit consists of a superheterodyne receiver, the decoding circuitry, a transmitter, and an integral power supply. It is fully transistorized except for the local oscillator and the pulsed triode

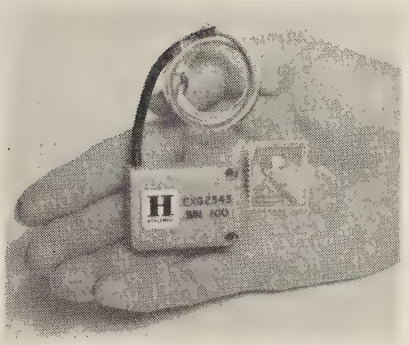
# Electronics

*write in item numbers on Reader Service Card*

transmitter oscillator, and requires less than 30 W from an external 28 V DC supply. It uses a pulsed triode output stage, affording reliability not previously attainable with magnetrons.

The triggering sensitivity of the S-C 702 is —70 dbm min. The unit can decode 38 distinct codes, permitting great flexibility in a high-density environment. The pulsed triode transmitter provides one-kilowatt output pulses of 0.25, 0.50, or 0.75 usec duration, and has a frequency stability of ±5 mc under all possible environmental conditions. The entire unit is sealed in an enclosure measuring 7⅛×-8¼×3⅜ in., and weighs about 10 lb. **56**

## Timers Use Magnetic-Core Oscillators



A family of solid-state magnetic core oscillators to be used as timers has been announced by Ordnance Div., Minneapolis-Honeywell Regulator Co., 600 Second St., N. Hopkins, Minn. It is based on the design of a timer developed for the Asroc missile.

The timers weigh only an ounce and have only 12 components. They provide time bases ranging from hundredths of a second to 100 seconds with an accuracy of 0.1 per cent over the range from —65 to 165 deg F.

Honeywell claims the timers are smaller, lighter, more reliable, and can withstand greater shock than conventional timers based on crystal, timing-fork, mechanical, or capacitance principles. Shock tests up to 4,000 g have been tried without damaging effect.

The timers use the controlled saturation of a magnetic core to obtain accurate time periods. They operate at extremely low pulse repetition rates, which do not require countdown stages in a five-second-per-cycle timer and only a few stages in longer-interval timers. The basic five-second magnetic oscillator consumes 8 milliamps at six volts and occupies one cubic inch of space. Each decade counter stage adds 1.5 milliamp and another cubic inch. Additional features include indefinite shelf life, the capability of setting desired time, and readout of unexpired time.

Applications of these devices include safing, arming, fuzing, and programming of mines, torpedoes, missiles, satellites, and gun-fired projectiles. **70**

**FERRITE ISOLATOR** — Miniature, lightweight, coaxial ferrite isolators with performance reported to be equal to that of larger units, are now available from **Sylvania Electric Products, Inc., Dept. S/A, 730 Third Ave., New York 17, N.Y.** The small size and high performance suit them ideally for aircraft and missile applications.

Typical of the new device is an X-band isolator with an isolation-to-insertion loss ratio of 20 to 1 and a 10 percent bandwidth.

No. 373 on Reader Service Card

LISLE *Magnetic* CHIP DETECTORS

Lisle Magnetic Chip Detectors provide early detection of internal breakdowns, assuring constant protection against in-flight failure.

Ferrous particles in a lubricant are a proven indication of excessive wear or impending breakdown. The Magnetic Chip Detector attracts these particles which bridge an electrically insulated gap in the Detector, completing a circuit which activates a warning light on the instrument panel.

Lisle Chip Detectors are used today in jet and reciprocating engines, accessory drives, propellers, constant speed drives and hydraulic systems in commercial and military aircraft.

*Write for Catalog and Samples for Testing*

LISLE CORPORATION
Clarinda, Iowa

No. 137 on Reader Service Card

**RADIO BEACON**–Development of a family of eight miniature HF-VHF-UHF radio beacons that can withstand the effects of an air drop has been announced by **Sunnyvale Development Center, Sperry Phoenix Co., Dept. S/A, Sunnyvale, Calif.** Each of the eight beacons covers a portion of the 2-260 mc region, with ranges up to 200 miles. A typical unit is a two-inch cube weighing 5 oz, operating at 220-260 mc, with an output of 500 mw.

No. 374 on Reader Service Card

**CABLE HARNESS**–A new approach to electronic Hookup cables and harnesses is "Spectra-Strip", a new multiconductor, flat bonded material. The cable, introduced by **Spectra-Strip Wire & Cable Corp., P.O. Box 415, Dept. S/A, Garden Grove, Calif.,** is composed of full sized conductors from 10 to 30 AWG. The color code is fully visible at all times. Special conductors such as coaxial, shielded wire, and thermocouple leads can be be built into the cable.

No. 375 on Reader Service Card

**OSCILLATORS** – A new family of two-cavity klystron oscillators has been developed for parametric amplifier pumping use and FM doppler radars. According to **Sperry Electronic Tube Div., Dept. S/A, Gainesville, Fla.,** an important feature is the constant output power versus beam voltage characteristic. This results in a flat top power output mode, permitting frequency modulation without excessive incidental amplitude modulation.

No. 376 on Reader Service Card

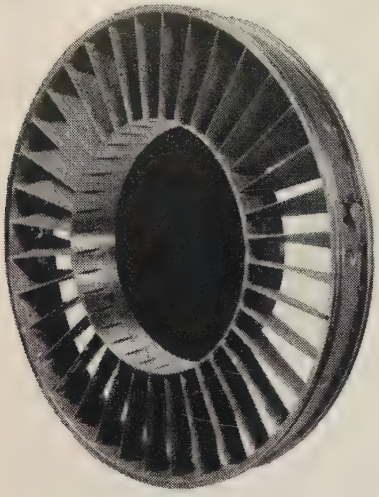
**WAVEGUIDE ISOLATORS**–Three transverse field, resonance absorption isolators, each designed to maximize load isolation and to maintain low insertion loss and VSWR to a low level are available for J-band, $X_N$-band, and $X_L$-band. Developed by **Motorola, Inc., Dept. S/A, 8201 E. McDowell Rd., Scottsdale, Ariz.,** they exhibit typical performance characteristics of 30 db minimum isolation, 1.0 db insertion loss, and 1.15 maximum VSWR.

No. 377 on Reader Service Card

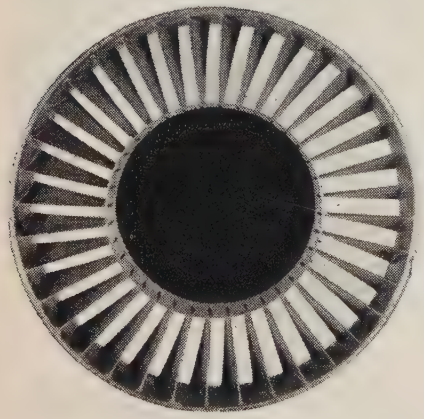
**TAPE RECORDER**–A 13 lb airborne magnetic tape recorder that records 14 tracks with laboratory precision in missile environments is a product of **Westrex Recording Equipment Div., Dept. S/A, 335 No. Maple Dr., Beverly Hills, Calif.** The 2101 data recording system consists of a precision tape transport and an electronic module assembly. Magnetic heads with gaps of 80 $\mu$inch make possible high frequency response in relation to tape drive speed.

No. 378 on Reader Service Card


# STALKER



# FABRICATIONS



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**The precision which is demanded by both aviation and nuclear equipment industries is insured through use of Stalker's exclusive ORTHOBRAZE fabrication methods.**

**Stalker services include product development, engineering, manufacturing, test facilities — U.S.A.F. approval No. MIL-Q-5923C.**

*Photographs courtesy of Lycoming Division, Avco Corp.*

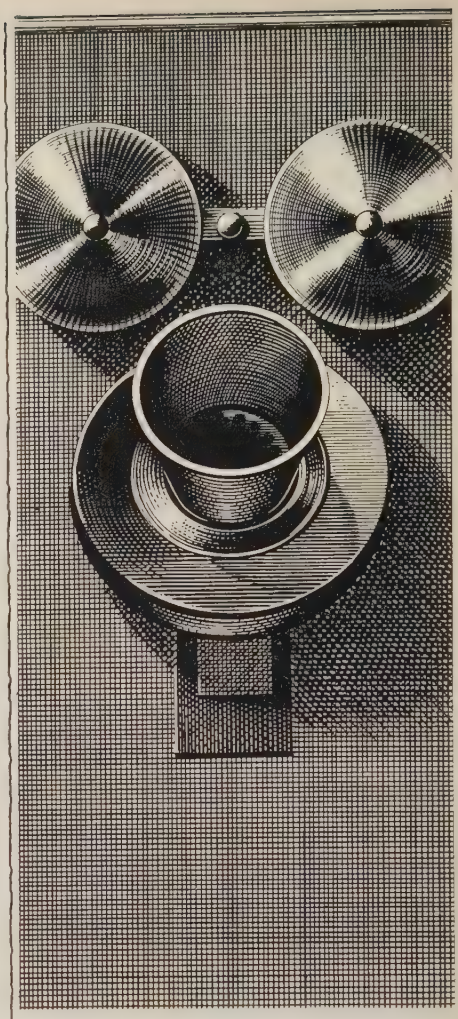
**THE STALKER CORPORATION**

**Phone: Bay City Twinbrook 3-7562**

**905 Woodside Ave. Essexville, Michigan**

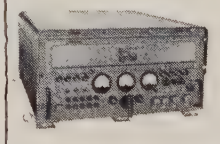
No. 138 on Reader Service Card





# TRANSMITTER

AN/URW-14A is a 100 watt command control transmitter which provides frequency-modulated carrier signals in the range of 406-549.5 megacycles. Carrier signal deviation may be selected from ±30 to ±300 kilocycles per second. An internal coder supplies twenty standard IRIG audio-frequency channels. External modulation up to 100 kilocycles can be utilized. Unit operates on 115 volts AC power. The unit is commonly used in the remote control of target and surveillance aircraft and in range safety applications where reliability counts. It is produced by Babcock, the world's foremost designer and manufacturer of remote control and guidance systems.



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**BABCOCK**

ELECTRONICS CORPORATION

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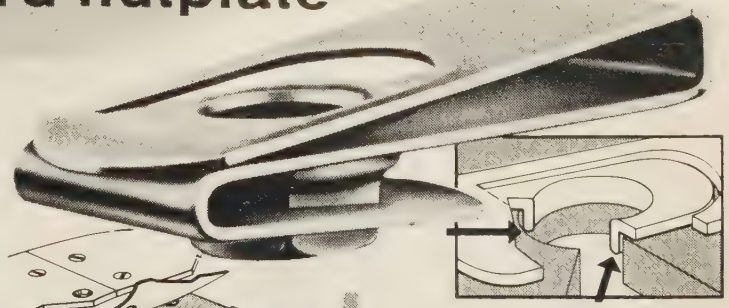
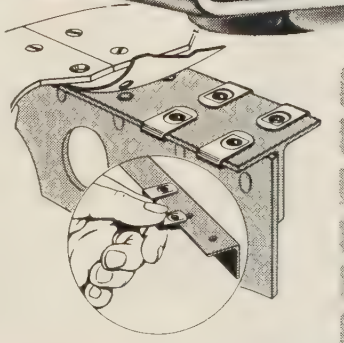
No. 139 on Reader Service Card

# Monadnock self-locking CLIP-ON NUT to replace standard nutplate

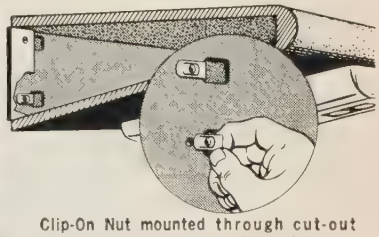
Eliminates costly riveting in structural and non-structural installations. Applied where suitable edge margin exists or through cut-out hole in center of panel, Clip-On Nut quickly slips onto panel or structure and locks firmly in bolt hole. Available for .020″ to .150″ application thicknesses. No tools required. As integral part of a sub-assembly, Clip-On Nut eliminates additional drawings, part numbers and installation in final assembly traditional with conventional locknuts. One airframe manufacturer reports a savings of 32c each time a Monadnock Clip-On Nut is used in place of nutplate. Clip-On Nut reduces inventory; simplifies design changes, field rework, repairs. Meets MIL-N-25027—120,000 psi class. Write for bulletin.



Drawn eyelet locates Clip-On Nut assembly in application hole. Controlled radius edges developed on eyelet (see arrows) insure smooth installation action.



Clip-On Nuts securing floor panels of Boeing 707 jetliner. Replace riveted nutplates where thickness of upper leaf is not objectionable and suitable edge margins can be provided.



Clip-On Nut mounted through cut-out hole in center of panel when edge margin is excessive.

AIRCRAFT DOT FASTENERS

**MONADNOCK MILLS • SAN LEANDRO, CALIFORNIA**

SUBSIDIARY OF UNITED-CARR FASTENER CORP., BOSTON, MASS.

OFFICES: ATLANTA, BOSTON, CHICAGO, CLEVELAND, DALLAS, DETROIT, LOS ANGELES, NEW YORK, PHILADELPHIA, SYRACUSE

No. 182 on Reader Service Card

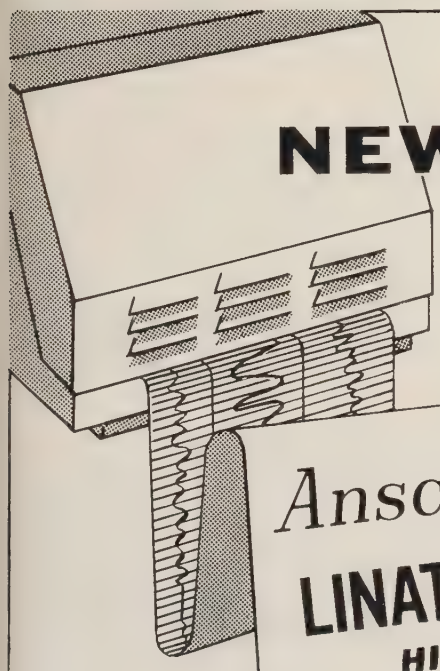


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Photo recording paper

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- **LATITUDE** covering the widest range of writing speeds. No need to
- **ECONOMY** stock several speed papers. New Linatrace A-4 allows
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No. 183 on Reader Service Card

# Use the Protection Proved at Over 3,300 mph

Rocket plane X-15 has reached an altitude of over 31 miles at a speed of more than 3,300 mph. ROKIDE Z coating on its engine exhaust area withstands temperatures above 4,000°F.

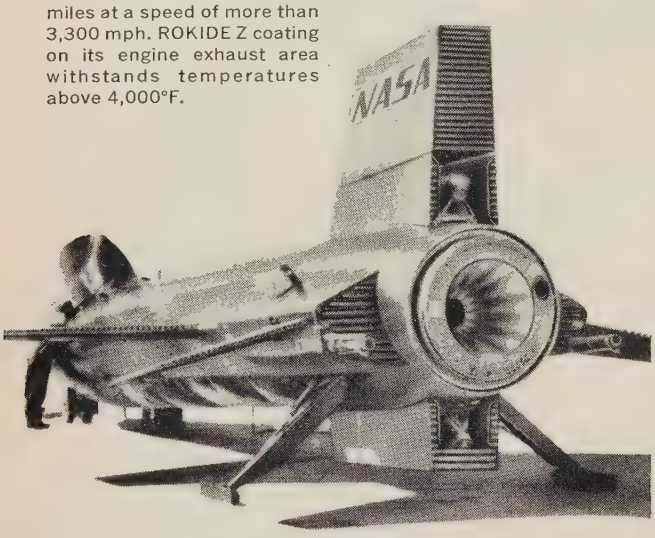



*Photo courtesy Reaction Motors Division, Thiokol Chemical Corp.*

## . . . *ROKIDE* Z coating*

In 80 seconds the 50-foot X-15, USAF-NASA-NAVY research aircraft, rocket propelled and manned, burns up in excess of half its 16-ton starting weight. To protect its XLR99 engine from the tremendous heat generated so quickly and intensely, Norton ROKIDE Z coating is used on the thrust chamber, throat and tail pipe.

What ROKIDE coatings have done for the X-15 and other space craft, they can do for your own developments. Among the large, fast-growing family of Norton refractories, ROKIDE Z zirconium oxide and ROKIDE A aluminum oxide offer maximum protection at minimum weight. In addition, experimental coatings for varying requirements are constantly being developed.

ROKIDE coating facilities are maintained in Norton plants at Worcester, Massachusetts, and Santa Clara, California — and by licensed applicators in key cities. For details, write to NORTON COMPANY, Refractories Division, 650 New Bond Street, Worcester 6, Massachusetts.

*Trade Mark Reg. U. S. Pat. Off. and Foreign Countries.

NORTON
REFRACTORIES
*Crystallizing ideas into products*

No. 132 on Reader Service Card




**ANALOG TO DIGITAL CONVERTER** — A family of superspeed subminiature converters has been developed that can reportedly carry out 5 to 30 million independent voltage data conversion operations per second. As announced by **Epsco, Inc., Dept. S/A, 275 Massachusetts Ave., Cambridge, Mass.**, the units are extremely small. A 7-bit mc converter, for example has a volume of seven cu in., exclusive of power supply. This new "ultra-speed" Datrac operates on a completely asynchronous principle and continuously digitizes a varying input providing a parallel coded output.

No. 379 on Reader Service Card

**COAXIAL ATTENUATOR** — This miniature coaxial remote controlled attenuator operates at a speed of 0.005 sec. It produces a "straight-through" coaxial connection when voltage is applied, reports **Don-Lan Electronics, Inc., Dept. S/A, 1131 Olympic Blvd., Santa Monica, Calif.** Upon removal of the operating voltage, this 2.85-oz attenuator becomes a 20 db bi-directional unit usable from 50 to 3500 mc. According to the company, it has excellent RF characteristics. Units are available for 28 volt DC or 115 volt AC operation. Designs meet MIL-E-5272C environmental specification requirements.

No. 380 on Reader Service Card

**FERRITE PHASE SHIFTER** — This reciprocal ferrite phase shifter spans a frequency range of 5.3 to 5.75 KMC or 5.75 to 6.2 KMC, reports **Electronic Communications, Inc., Dept. S/A, 1830 York Road, Timonium, Md.** It has a phase shift of 0 to 360 deg minimum; insertion loss is 1 db maximum. The phase shifter is 7.5 in. long and weighs 4.25 lb, including the coil. The required field at 360 deg is 100 oersteds at 5.3 KMC and 250 oersteds at 6.2 KMC. The 0.5-ohm coil requires 2 to 5 amperes.

No. 381 on Reader Service Card

**PHOTOELASTIC DELAY LINES** — Delays up to 160 microseconds at frequencies up to 30 megacycles have been reported with photoelastic ultrasonic delay lines. Features include multiple tapping without loss of signal and addition and multiplication of two or more signals, says **Corning Glass Works, Dept. S/A, Corning, N. Y.** A continuously variable delay is possible because the output can be tapped at any point along the solid transparent delay line medium.

No. 382 on Reader Service Card

**RADIO INTERFERENCE FILTERS** — Filters available in seven basic case sizes, voltage ranges of 150 and 250 volts ac, current ratings of 0.4 to 100 amps, and six different types of mounting brackets have been announced by **All-Tronics, Inc., Dept. S/A, 45 Bond St., Westbury, N. Y.** Units are designed to meet military specs, says the company. Different terminal designs are also available: threaded, 45 or 40-deg solder, or shielded lead. Standard units have 1-week delivery.

No. 383 on Reader Service Card

**MODULATOR** — This modulator can be operated as either an integral unit or for remote systems as far as 1000 feet away. Developed by **Manson Laboratories, Inc., Dept. S/A, Stamford, Conn.**, the unit provides for continuous tuning of a magnetron and also permits work from a tower. The modulator represents Manson's latest development in the modulator field.

No. 384 on Reader Service Card

**LIMIT SWITCH**—A limit switch featuring solid-state electronics and high reliability has been introduced by **Texas Instruments Corp., Dept. S/A, P.O. Box 66027, Houston 6, Tex.** The new unit, called the "Statronic" limit switch, has no make or break electrical contacts and may be used in any application where roller-lever actuated switches are employed. The switch requires standard 115 volt a-c input power and has an operating temperature range from 0 to 200 deg F. It is impervious to moisture and corrosive atmospheres.

No. 385 on Reader Service Card

**IR DETECTOR COOLER**—Thermoelectric coolers; capable of achieving —140 deg F, are now available from **Pesco Products Div., Borg-Warner Corp., Dept. S/A, Warner, Ohio.** This compact unit consists of an infrared detector cell mounted on a four-stage cascaded thermoelectric cooler, all installed within a vacuum enclosure. The four-stage cascade is capable of cooling a 15-mw load to —78 deg F, when used with a +27 deg C heatsink.

No. 386 on Reader Service Card

**READOUT PANELS**—Two electroluminescent panels for the display of numeric and alpha-numeric information have been developed by **Sylvania Electric Products, Inc., Dept. S/A, 730 Third Ave., New York 17, N.Y.** The 1-½-in. panels are composed of segments of electroluminescent lamps, insulated from each other and individually terminated.

No. 387 on Reader Service Card

## DATA FILE

**MODULES**—A series of data sheets and a six-page brochure describing regulated dc power supply modules are available from **Varo, Inc., Dept. S/A, 2201 Walnut St., Garland, Tex.** The publications list operating theory, schematic diagrams, and specifications.

No. 388 on Reader Service Card

**RECTIFIER**—A single-page data sheet describing a 1000-watt, d-c output bridge rectifier is offered by **Varo, Inc., Dept. S/A, 2201 Walnut St., Garland, Tex.** The data sheet lists features, includes complete electrical specifications.

No. 389 on Reader Service Card


# CLAMPS by WITTEK

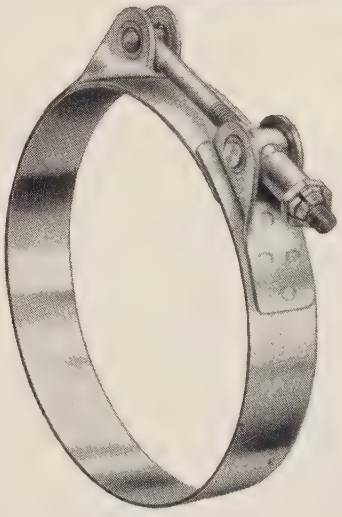
## for the *Space-Age*

### STAINLESS STEEL FLAT BAND CLAMPS

*Complete range of sizes from 2¼" to 10" diameter*

Quick-Latch Clamp—Series 10QL

Meets rigid military standards where easy installation and removal are important. The patented latch construction gives positive assurance against accidental disconnect. Basic materials and components meet MS requirements governing Part MS21920R.

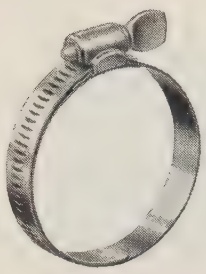


T-Bolt Clamp—Series 10T

Same as 10QL but without patented quick-latch, and recommended for more permanent applications. Meets MS requirements governing Part MS21920.

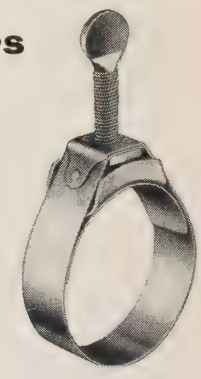
### STAINLESS STEEL AIRCRAFT CLAMPS

*Complete range of sizes*



Type AN737-TW (with shoe)

Type AN737-TWLS (without shoe)



Type AN737-RM (floating bridge)

Descriptive literature or recommendations for any clamping requirements upon request.

*Quality Clamps for over a Quarter Century*

**WITTEK MANUFACTURING CO.**

**4368 West 24th Place, Chicago 23, Illinois**

CLAMPS for Every Application

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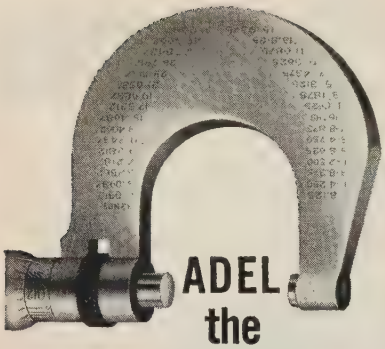

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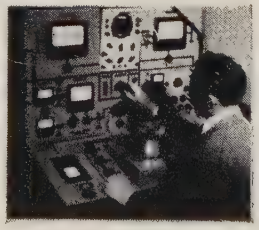
*Very High Production Standards*

*Rigorous Quality Control*



*Firing Accuracy*

**SS.10 SS.11**

*Anti tank missiles designed and manufactured by*

NORD-AVIATION 2 a 10, RUE BERANGER · CHATILLON s/s BAGNEUX · SEINE · TEL. ALESIA 57-40

No. 188 on Reader Service Card


**MICROCIRCUITRY**—A catalog describing microcircuitry devices available as standard circuits is available from **Varo, Inc., Dept. S/A, 2201 Walnut St., Garland, Tex.** Featured in the catalog are descriptive data on digital, computer, control, and audio frequency circuits.

No. 390 on Reader Service Card

**PULSE COMPRESSION** — A catalog page describing pulse compression networks and outlining applications and advantages is available from **Ortho Filter Corp., Dept. S/A, 7 Paterson St., Paterson 1, N.J.** It provides a typical response curve of time delay versus frequency, illustrating the linear range.

No. 391 on Reader Service Card

**ANGLE REPEATER**—A two-page specification sheet describing the Model PPR-10 position repeater is available from **Theta Instrument Corp., Dept. S/A, 520 Victor St., Saddle Brook, N.J.** Block diagrams, special features and performance data are included.

No. 392 on Reader Service Card

**DIODE GATE**—Technical Bulletin 60-Q, describing the type 2011 logix block diode gate, is offered by **Rese Engineering, Inc., Dept. S/A, A and Courtland Sts., Philadelphia 20, Pa.** The bulletin provides photographs, a block diagram, typical logical configurations and complete characteristics.

No. 393 on Reader Service Card

**SEMICONDUCTOR**—A 12-page short-form catalog describing a complete line of microwave semiconductor products is available from **Microwave Associates, Dept. S/A, South Ave., Burlington, Mass.** Electrical and mechanical specifications plus outline drawings with dimensions are given.

No. 394 on Reader Service Card

**POTENTIOMETER WINDER**—A catalog sheet that illustrates and describes Model 435-AML precision potentiometer winder has been published by **Geo. Stevens Mfg. Co., Inc., Dept. S/A, Pulaski Rd. at Peterson, Chicago 46, Ill.** The sheet lists specifications and includes operating information for the unit.

No. 395 on Reader Service Card

**CAPACITORS**—A comprehensive 16-page booklet describing and illustrating a line of ceramic capacitors is offered by **Gulton Industries, Inc., Dept. S/A, 212 Durham Ave., Metuchen, N. J.** The units are indexed in terms of reliability specifications, military part numbers and range of temperature characteristics.

No. 396 on Reader Service Card

**AIRBORNE RADIO**—A 12-page brochure outlining extensive radio equipment for airborne communication is available from **Marconi's Wireless Telegraph Co., Ltd., Dept. S/A, Chelmsford, Essex, England.** Specifications and features are presented for the equipment.

No. 397 on Reader Service Card

**DELAY LINE**—A data bulletin that gives a complete description of the Type 192 magnetostrictive delay line is available from **Deltime, Inc., Dept. S/A, 608 Fayette Ave., Mamaroneck, N. Y.** Complete applications data, including specific graphic operational characteristics are offered.

No. 398 on Reader Service Card

**OPTICAL ENCODERS**—An eight-page catalog covering linear and sine-cosine precision optical encoders is available from **Computer Control Company, Inc., Dept. S/A, 983 Concord St., Framingham, Mass.** Also included are encoder principles of operation, applications, packaging features.

No. 399 on Reader Service Card

**AGC AMPLIFIER**—Bulletin TN 1020 describes an automatic gain control amplifier used in a resolver servo, dividing servo, and special function generator. Issued by **Melcor Electronics Corp., Dept. S/A, 48 Toledo St., So. Farmingdale, N. Y.,** it includes methods for checking AGC range and transient response, in addition to a schematic diagram.

No. 400 on Reader Service Card

**WAVEGUIDE PRODUCTS**—A 4-page leaflet describing such products as a high power rotary joint, stripline power divider, resistive loop directional coupler, optical waveguide arc detector, and others, is now available from **FXR, Inc., Dept. S/A, 25-26 50th St., Woodside 77, N. Y.** It also gives brief information on the capabilities of the company's microwave division, as well as engineering and production facilities.

No. 401 on Reader Service Card

**DATA SYSTEM**—Information and specifications on a portable data gathering system are included in a brochure issued by **Epsco System, Dept. S/A, 275 Massachusetts Ave., Cambridge 39, Mass.** A block diagram is included for this unit, which reportedly can supply the capability of large-scale, multi-rack installations in two compact, portable carrying cases.

No. 402 on Reader Service Card

**NEW THERMOSTAT COMBINES FOUR DESIGN ADVANTAGES**

**Only the KLIXON M2 THERMOSTAT** brings you all four of these desirable features:

1. the dependability of a snap-acting bimetallic disc;
2. a differential range as narrow as 2° to 5°F;
3. a welded hermetic seal;
4. a switch-action option of opening or closing on temperature rise or drop.

Features (3) and (4) are exclusive . . . and what a rewarding difference they make.

**The KLIXON M2 Welded Hermetic Seal** prevents contamination of the thermostat due to trapped solder or flux. Moreover, you're sure that the seal is free of voids or undetected weak spots that might lead to corrosion. So, you get extra assurance of long-lived performance.

**THE KLIXON M2 Optional Switch Action** allows you to use the same basic thermostat not only to control temperature in heating boots and blankets and anti-fogging systems but also to turn on warning lights when temperatures get too high.

**Write Today** for complete specifications, prices, delivery schedules or packaging design assistance.

**PERFORMANCE CHARACTERISTICS of M-2 THERMOSTAT**

| | | |
|---|---|---|
| Calibration | 0-250°F Standard ±4°F on closing temp<br>Special ±3°F on closing temp | |
| Differential | 0-250°F 5 to 9°F or 2 to 5°F<br>251-350°F 5 to 9°F | |
| Temp settings | −65 to 350°F<br>350 to 450°F under development | |
| Switch action | SPST, closes on temp rise or temp drop | |
| Electrical rating | Amperage (non-inductive) | Cycles |
| Voltage<br>30 V-dc/120 V-ac | 2 amp | 250,000 cycles |
| Dielectric strength | 1250V rms, 60 cycles for 30 sec | |
| Vibration resistance | 5-500 cps at 10 G's accel. or .36 D.A. | |
| Leakage | Surpasses immersion test MIL-E-5272C | |
| Approximate weight | 5.6 grams | |

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## *Electronics*

**WAVEGUIDE COMPONENTS**—A new catalog has been announced by **Microtech, Inc., Dept. S/A, 1425 Milldale Rd., Cheshire, Conn.** It gives complete information on the company's line of waveguide components including flexible wave-guide, soldered convoluted waveguide, and elbows and twists.

No. 403 on Reader Service Card

**SELENIUM RECTIFIERS**—Bulletin 101 describes a line of selenium rectifiers covering ranges from micro to kiloamperes and voltages from milli to kilovolts, which are available from **Edal Industries, Inc., Dept. S/A, 4 Short Beach Road, East Haven, Conn.** Several types of arc suppressors and contact protectors are also shown.

No. 404 on Reader Service Card

**SCATTER SYSTEMS**—"Latest And Future Trends In Tropospheric Scatter Communications," a technical paper, is available from **Adler Electronics, Inc., Dept. S/A, 1 Lefevre Lane, New Rochelle, N.Y.** The paper covers technical, packaging, and economic factors in fixed and transportable troposcatter systems.

No. 405 on Reader Service Card

**TAPE RECORDER** — A bulletin has been issued by **Leach Corp., Dept. S/A, 18435 Susana Rd., Compton, Calif.**, on what are reportedly the smallest, most rugged miniature magnetic tape recorders manufactured. The brochure includes information on an analog record system, wideband FM record system, and carrier erase record system. Detailed data for various airborne components is also included in the booklet.

No. 406 on Reader Service Card

**COMPONENTS**—Components used in the electronics industry are fully illustrated and described in a catalog issued by **National Tel-Tronics Corp., Dept. S/A, 52 St. Cosimer Ave., Yonkers, N. Y.** The products covered include tip plugs and jacks, as well as banana plugs, non-insulated and insulated.

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**SPACE SYSTEMS**—In a 24-page illustrated booklet, **Kollsman Instrument Corp., Dept. S/A, 80-08 45th Ave., Elmhurst 73, N.Y.,** discusses the company's background for the development of missile and space systems. It includes information on the MD-1 automatic astro compass system used in the B-52, various star trackers, navigators, and computers, as well as aerospace ground equipment.

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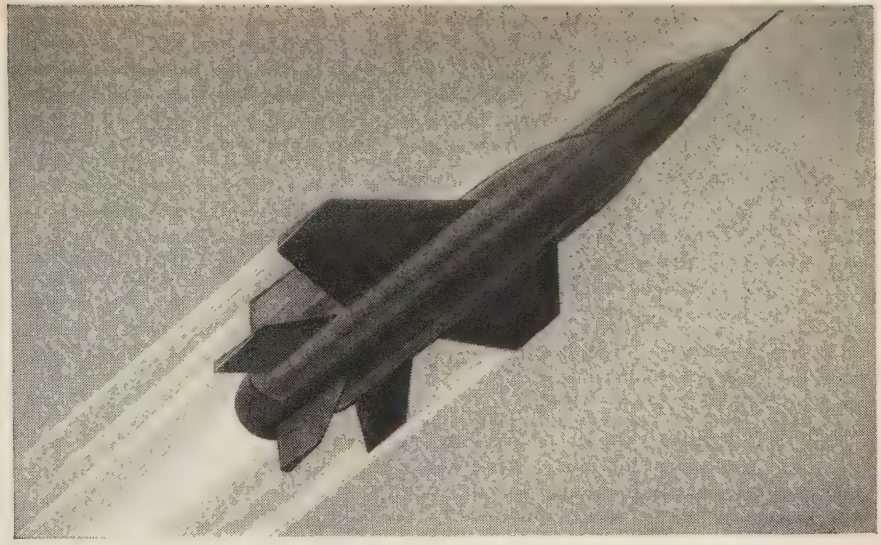

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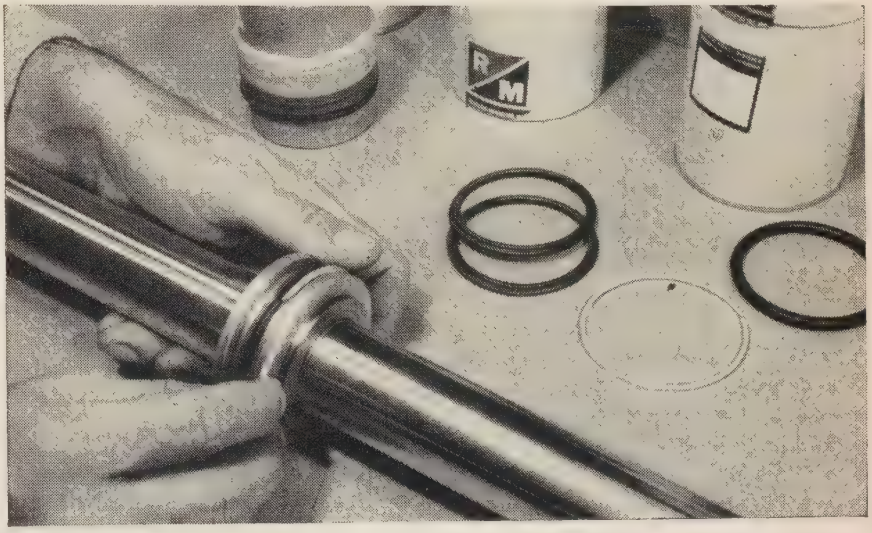


Raybestos - Manhattan capability was clearly demonstrated when it solved the extremely difficult problem of fabricating anti-extrusion rings for a super-secret rocket plane.

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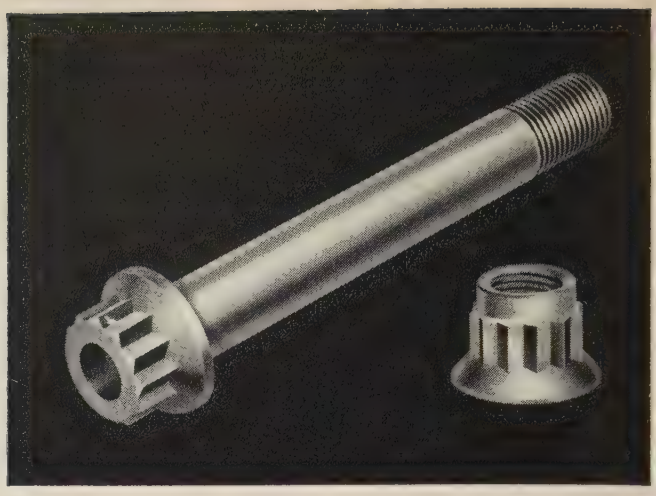
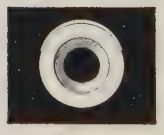


Designing with the SPS EWB 30 bolt means working with a fastener which has nearly twice the ultimate tensile strength of 10 years ago (1951—160,000 psi, 1961—300,000 psi); a proportional increase in shear (1951—95,000 psi, 1961—180,000 psi); and three times the fatigue endurance (1951—40,000 psi, 1961—120,000 psi). The EWB 30 has a strength-to-weight ratio comparable to that of titanium.

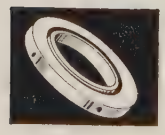
This "new era" bolt is fabricated of vacuum melted steel, cadmium plated by vacuum deposition to eliminate hydrogen embrittlement. The result is a fastener certified by SPS for the 300,000 psi level.

To insure the full use of the EWB 30's inherent strength, SPS offers a complete fastening system, which permits a full 80% of the yield strength to be realized. System components include:

- Specially designed socket wrench—contacts bolt head or nut in stronger midportion of wrenching areas



- Load bearing washer—prevents loss of clamping force through indentation of either bolt head or nut into materials being fastened



- Preload Indicating Washer (PLI)—accurate preloading to 80% of yield can be achieved consistently

EWB 30 and FN 30 locknuts are available in sizes #10-32 through ¾-16. A shear bolt and nut combination is available in protruding (EWSB 30) and flush head styles (FST 30, FSH 30) for 180,000 psi shear strength.

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No. 191 on Reader Service Card

# How engineers feel about overtime

"A FAIR PORTION of overtime is generally manufactured by the engineer out of his interest and concern for a project," says one member of this month's 115-engineer Reader's Round Table. Most of the others seem to agree with him.

Only four of the 115 say that they never work overtime if they can help it. Most others put in some extra time on their own hook, either because they can get more done in the quiet of an empty office or just "finishing work on some idea that occured late in the day and was too interesting to put aside."

The Round Table respondents don't like compulsory, scheduled overtime, and are inclined to think that at least some of the deadline pressure that makes it

**Q. How many hours of overtime do you put in in a typical week?**
**A.** None: 36 1-2: 18 3-4: 17 5-6: 15 7-8: 15 More than 8: 14

**Q. How many hours of overtime do you put in in your busiest weeks?**
**A.** None: 4 1-5: 6 6-10: 34 11-15: 16 16-20: 33 21-25: 6 26-30: 8 More than 30: 8

**Q. About how many times a year do the "busiest" weeks come along?**
**A.** Once: 7 2-3 times: 32 4-5 times: 31 6-10 times: 21 11-15 times: 8 16-20 times: 2 More than 20 times: 5

**Q. How much of your overtime is paid?**
**A.** None: 69 Less than 50%: 9 50% or more: 16 All: 19

**Q. If overtime is paid, at what rate?**
**A.** Straight: 22 Premium: 22

**Q. Do you think engineers should get overtime pay?**
**A.** Yes: 89 No: 26

**Q. Do you deliberately leave certain jobs for your overtime hours?**
**A.** Yes: 32 No: 82

**Q. When do you put in your overtime?**
**A.** After regular working hours: 107 Before regular working hours: 14 Working through lunch: 21 Week-ends: 103

**Q. Do you think most of your overtime is necessary and unavoidable?**
**A.** Yes: 78 No: 30

**Q. How effective are your first eight hours of overtime compared with regular working hours?**
**A.** More effective: 29 Same: 34 75-99%: 34 50-74%: 10

**Q. How effective are your second eight hours of overtime compared with regular working hours?**
**A.** More effective: 2 Same: 11 75-99%: 23 50-74%: 27 25-49%: 8 Less than 25%: 1

**Q. How do you think the amount of overtime you put in compares with your supervisor's?**
**A.** More: 28 About the same: 50 Less: 36

**Q. With other engineers' in your department?**
**A.** More: 39 About the same: 53 Less: 21

**Q. How do you rate overtime as a factor in job dissatisfaction?**
**A.** Very important: 14 Moderately important: 33 Minor: 61

**Q. How many hours a week do you spend on work not required by your company or necessary to your job, but necessary or valuable to you as an engineer (e.g., study, research, reading technical books and periodicals)?**
**A.** None: 4 1-2 hours: 17 3-4 hours: 31 5-6 hours: 21 7-8 hours: 21 More than 8 hours: 26

**Q. Are you attending formal classes in engineering or a related field?**
**A.** Yes: 28 No: 87

**Q. How many hours a week (excluding regular working hours, lunch hours, and attendance at engineering meetings, conferences, etc.) do you spend "talking shop" with colleagues or friends?**
**A.** None: 20 1-2 hours: 38 3-4 hours: 20 5 or more hours: 25

**Q. Considering interruptions, distractions, and the like, how do you rate the level of efficiency of the average engineer in your department or group on a typical working day?**
**A.** 100%: 1 90-99%: 8 80-89%: 26 70-79%: 45 60-69%: 18 50-59%: 6 Less than 50%: 6

necessary could be taken off by better planning. However, most of them accept it as an occupational hazard of the aerospace industry.

The typical respondent works about three hours of overtime in an average week, and 11 hours in his busiest weeks, which come along about four times a year. He doesn't get paid for any of it.

**Who rates overtime pay when?** The panel comes out strongly in favor of overtime pay for engineers, but a good many men qualify their answers. Eleven specify that only engineers in the lower salary and responsibility brackets should get paid for overtime; 26 say that only scheduled overtime should be compensated.

Most of the engineers who argue against overtime pay think it's inconsistent with professional status: "A professional man is hired to do a job, whether it takes 20 hours a week or 80 . . ." "Except for engineers at the very bottom of the salary ladder, I do not believe overtime pay is consistent with true professional recognition . . . " "I would like the engineer to be handled like a truly professional man as much as possible."

**"Engineers are hired hands . . ."** Two respondents say that, since they aren't treated like professionals anyway ("my experience is that engineers are simply hired hands"), they should at least get the extra money.

Several think that overtime pay is "probably the best way to discourage management from using overtime," and "necessary to keep a company from abusing the employees." Half a dozen would be glad to settle for more flexible regular working hours or compensatory time off.

Standing on professional dignity in the matter of overtime pay appears to be something of a luxury. The 26 men who answered "no" to the pay question earn an average of $14,222 a year, well above the 115 respondents' average of $11,662. The 89 who answered "yes" average $11,411.

Answers to the question, "What types of work do you usually do on overtime?" gave first place to proposal writing and other engineering paperwork (45 mentions). Design and analysis came next (24 mentions), followed by testing and production troubleshooting (19). Then came non-engineering paperwork (18), planning (16), and consulting with coworkers (12).

**"Freedom from the telephone . . ."** "Most creative work seems easier to do in the relative quiet of after hours," says one of the 31 engineers who answer "yes" to "Do you deliberately leave certain jobs for overtime?" Most of the others agree with him. "When I know I am going to put in overtime, I leave some things that require a little more concentration . . ." "During working hours, you usually have to make many starts after losing your train of thought . . ." "Freedom from the telephone permits better concentration."

The 29 men who say they find their first eight hours of overtime more effective than their regular working hours make the same kind of comments. Most of the respondents consider the first eight overtime hours highly productive—only 10 of the 107 men who made estimates rate their effectiveness during those hours at less than 75 per cent of normal.

After the first eight hours, the effectiveness of overtime work drops off somewhat; but still, only 9 of the 75 men who made estimates for their second eight hours gave this period a rating of less than 50 per cent.

Several engineers mention that "it depends somewhat upon whether we are talking about the first week or the fourth week." Top effectiveness can be maintained for a week or two of heavy overtime under deadline pressure, but "regular overtime results in reducing accomplishment total to that normally done on a 40-hour week."

**Head starts would help** Quite a few, though, have less drastic suggestions: better planning by supervisors and management (mentioned 23 times), more staff (20), and better cooperation from customers and subcontractors (8). Specifically, several men think deadline pressure could be reduced if their companies would let them get a head start on drafting proposals and working up preliminary designs "for jobs which are anticipated before requests for bids come in."

The one man who claims that engineers in his department operate at 100 per cent efficiency during the regular working day explains that "our situation is unique in that each engineer has a private office where he can shut himself off from distractions."

**How efficient can you get?** Most of the others seem to consider 100 per cent efficiency a theoretical impossibility: "The human is psychologically unable to be efficient for periods exceeding one-half hour . . ." "An extraordinary man may be 90-95 per cent efficient for the first half-day, 85-90 per cent for the second."

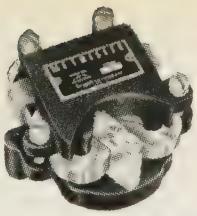
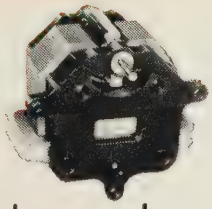
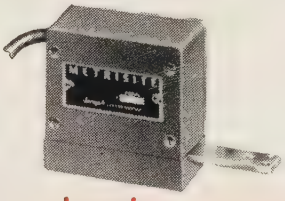
Many respondents feel that an engineer is efficient only when he's engineering, and include hours spent on such unavoidable features of the working day as paperwork, conferences, and consultations in their percentages of wasted time. "Interruptions by sales department, advertising, personnel, safety suggestion committees, plant troubles . . ." "Subordinates looking for information or help which I feel they could find or do themselves . . ." "People who ask questions instead of solving problems . . ." are specified as efficiency-reducers. So are poor planning (again) and the resulting uneven workload, poor physical facilities, bull sessions, and, of course, paperwork.

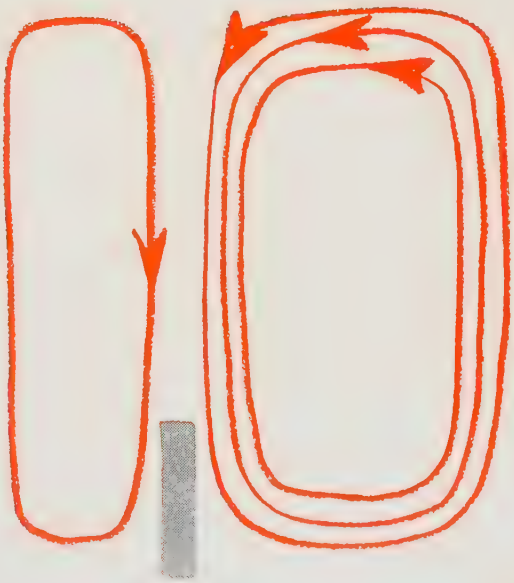
The 28 men who think they work harder than their supervisors may be right, but they almost certainly don't work as hard as their supervisors' supervisors.

**More work for higher pay** The Round Table questionnaires offer pretty impressive evidence of the correlation between high pay, high status, and heavy workload. Only four of the 21 men who earn less than $10,000 a year regularly put in five or more hours a week of overtime. The hardest-working member of the group regularly puts in eight extra hours.

Of the 21 who earn $18,000 a year or more and/or have managerial jobs, 15 work five or more overtime hours a week and nine average eight hours or more. Two of them—a 40-year-old division manager, earning $22,500 a year in an 800-employee company, and a 39-year-old, $20,000-a-year director of engineering in a 100-employee firm—say that they regularly work a 60-hour week and put in up to 80 hours when they're really busy, 10 or 12 times a year. Only one man—an $18,500-a-year senior technical specialist—has managed to combine high salary with no regular overtime.

The difference in the two groups' work loads virtually disappears at deadline time, however. Nine men in

Metrisite... is the only  device available today that  provides a near-perfect combination of ideal transducer characteristics. The unusual properties of this remarkable new motion-sensing development are: extreme resolution...  easily measures one ten-millionth of an inch; minute operating force... absolute minimum bearing friction; negligible reactive force... a fraction of a milligram; true linearity... a proven accuracy of 1/10%; high electrical output... up to 100 volts without amplification; wide range of shapes and sizes... from sub-miniature on up; exceptional ruggedness... can meet military shock and vibration tests. Now, many of the obstacles that have plagued control technology can be eliminated. Write for Metrisite details.



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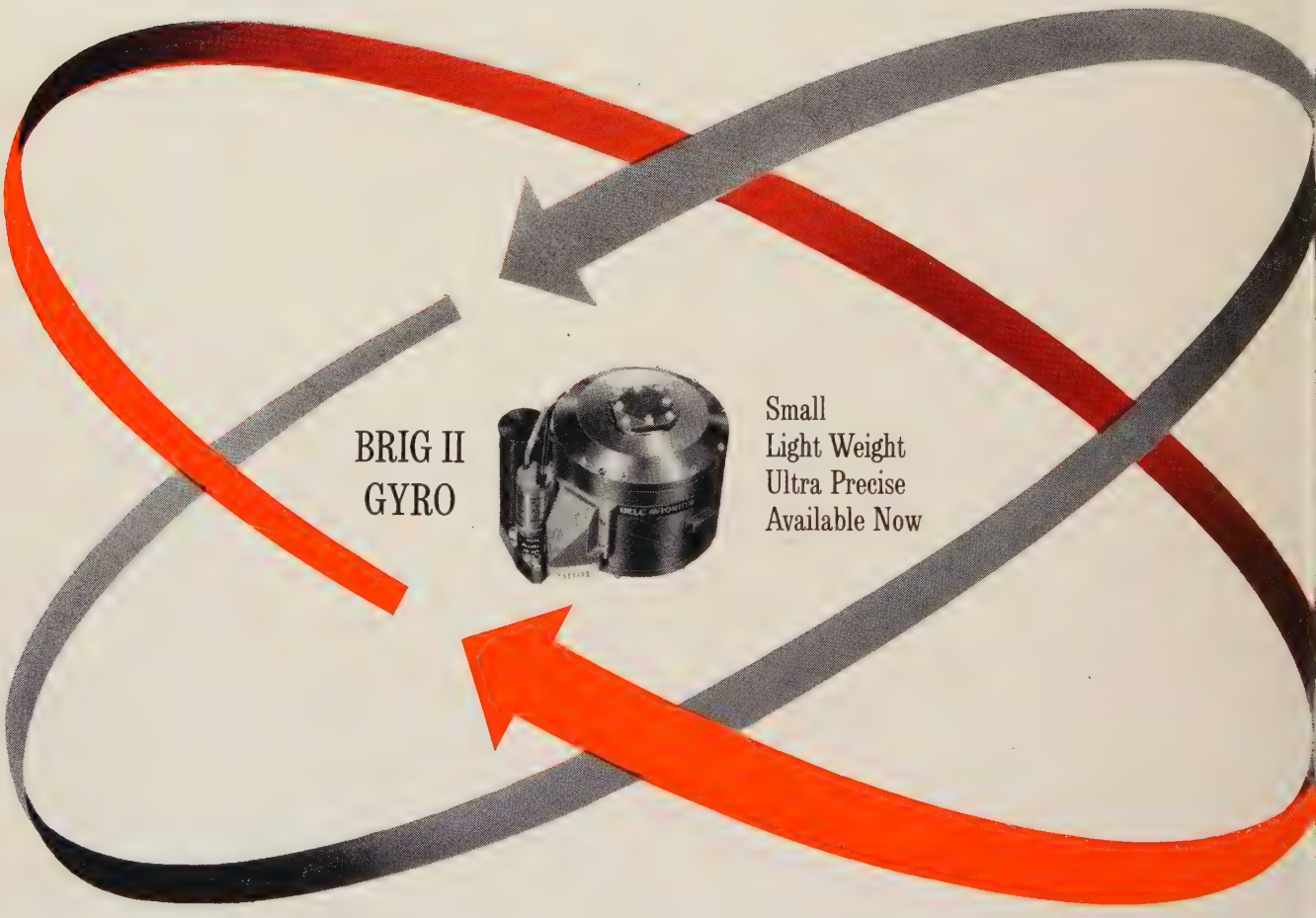


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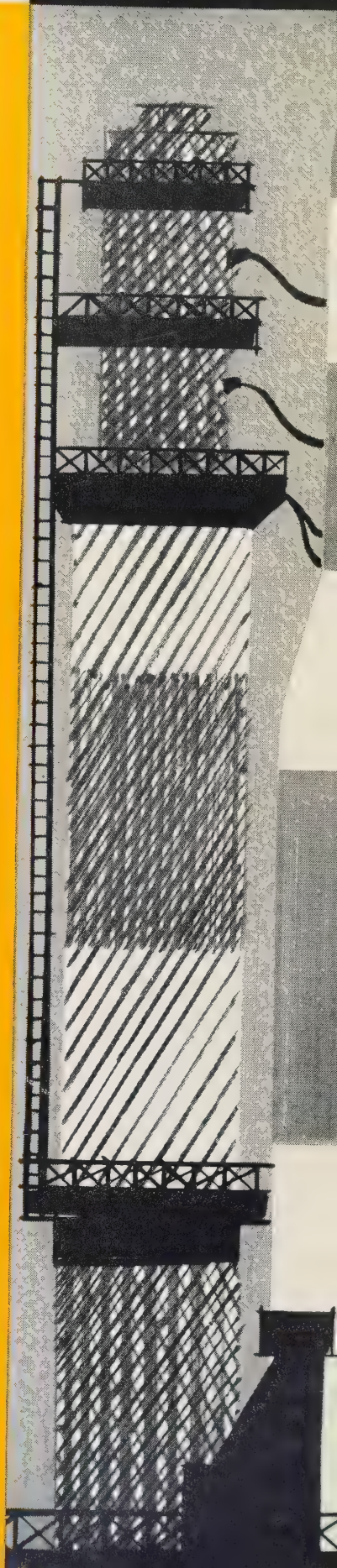
# Ground Support Technology

.....Design Trends & Requirements

.....Index to Company Capabilities

.....Company Specialties & Contract Experience



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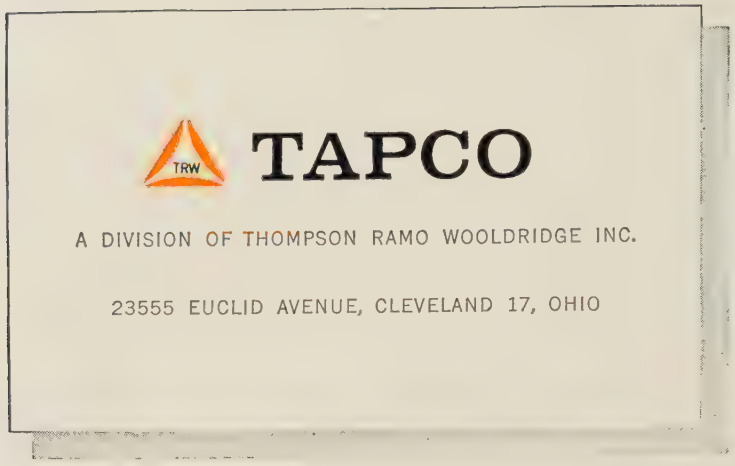


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# Ground Support Technology

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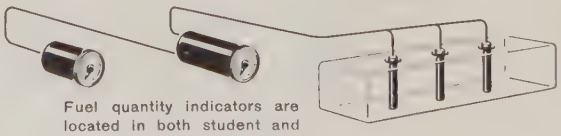

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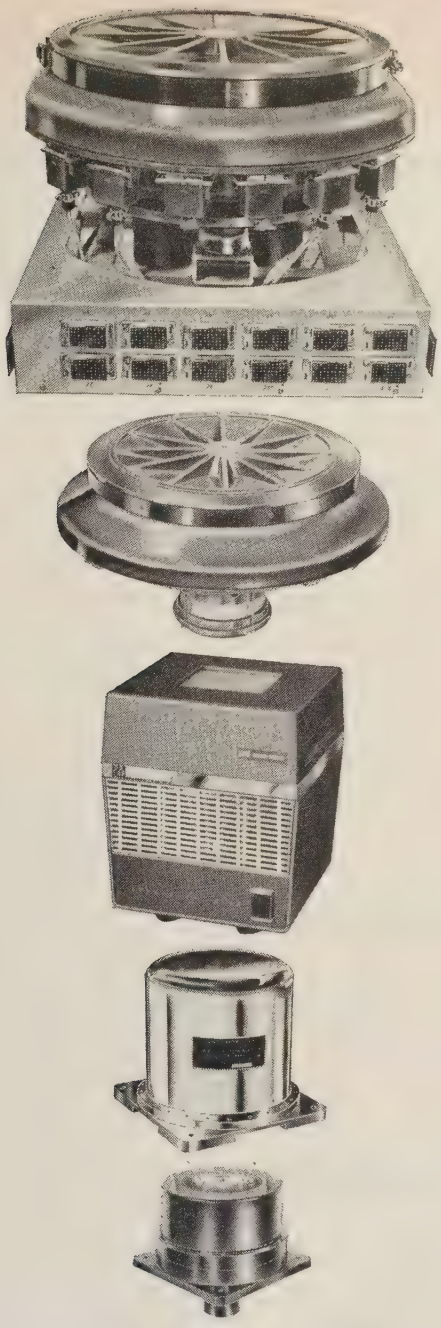

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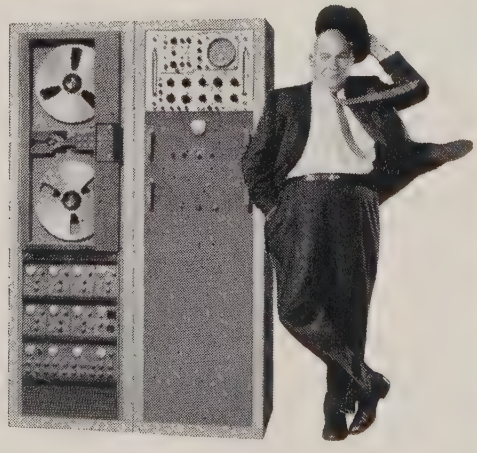

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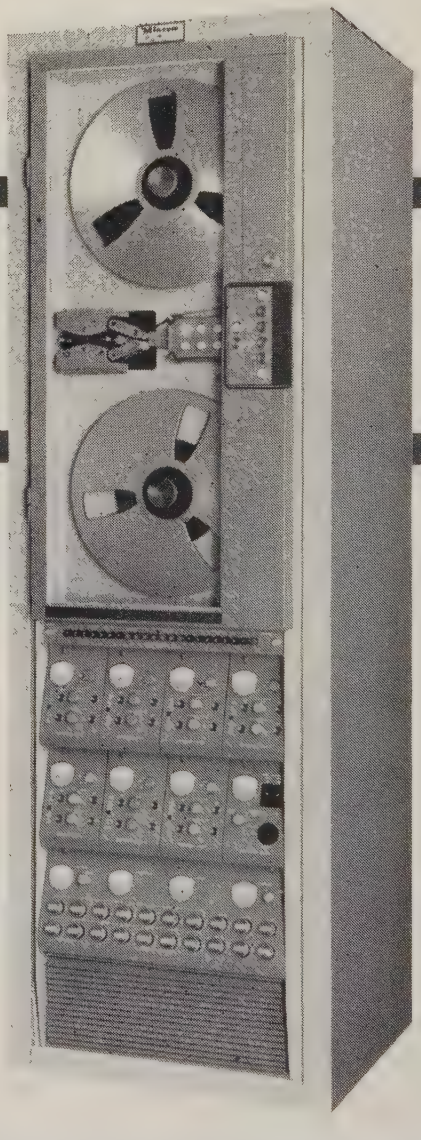

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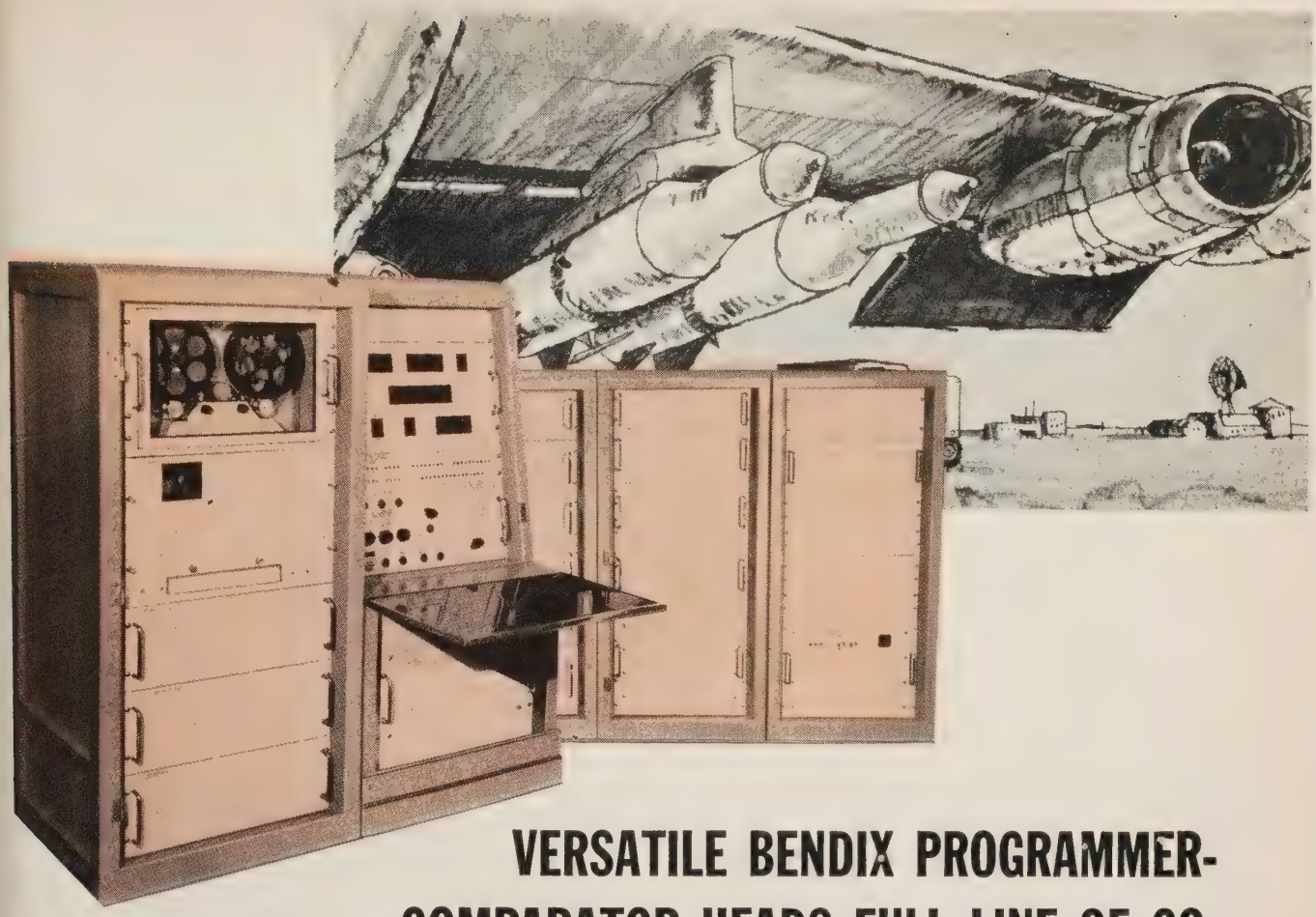

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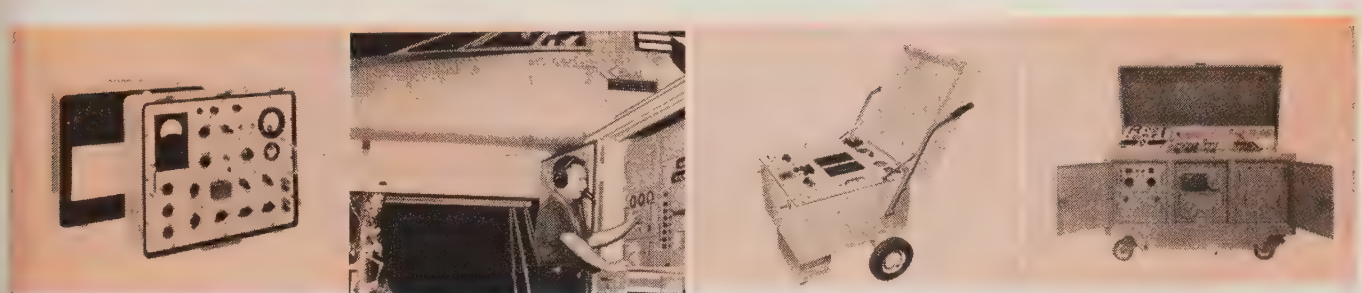

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# Booster Support

- *Rail and highway transport getting tougher*
- *More complex transfer systems for liquids*
- *Segmentation to solve solids' weight problem*

**by Irwin Stambler,** Associate Editor

THE PRINCIPAL FEATURES of advanced boosters support are standardization, simplification, and the combination of functions in a single piece of equipment. Nuclear support, with its requirement for remote handling, probably is the only exception to these trends.

The main problems confronting the designer of booster support equipment today basically are those of size and weight. In view of the greatly increased sizes of upcoming solid and liquid rockets, the trend away from long-range highway transportation probably will continue. Highway transport has already been eliminated almost completely in favor of C-133 air transport for current missiles like Atlas and Titan. The Atlas' tubular missile handling dolly, for instance, has two small wheels on its sides that ride on guide rails into the C-133 after the assembly is detached from cab, axles, and wheels.

Actually, for air transport, too, increasing size and weight are beginning to cause too many headaches. (Weight, of course, is more of a problem for solid boosters than for liquid ones.) The alternative is either rail or water transport. The use of segmented designs generally is seen as the best method for keeping the weight problem of solids manageable. Segmenting apparently will also be used more widely for the support equipment itself (for both solids and liquids). A case in point, engineers at General Dynamics Astronautics Division told SPACE/AERONAUTICS, is a tool to be used for checking the interfaces. To provide maximum accuracy, this should be a one-piece tool—but then it would be too large to ship. It will therefore be made in sections and assembled at the launch site, where there will then have to be a master tooling jig to check the tool itself.

Because of the large size of upcoming vehicles, there is likely to be a trend to more coastal operations, with assembly plants placed nearby. Even so, outsize trailers will still be needed in the launch area. Unfortunately, these trailers would be uneconomical if used on the base and at the same time simply too large for our highway system. The answer, it's been suggested, is to build the trailers in segments for highway trips and then put them together for use on the base.

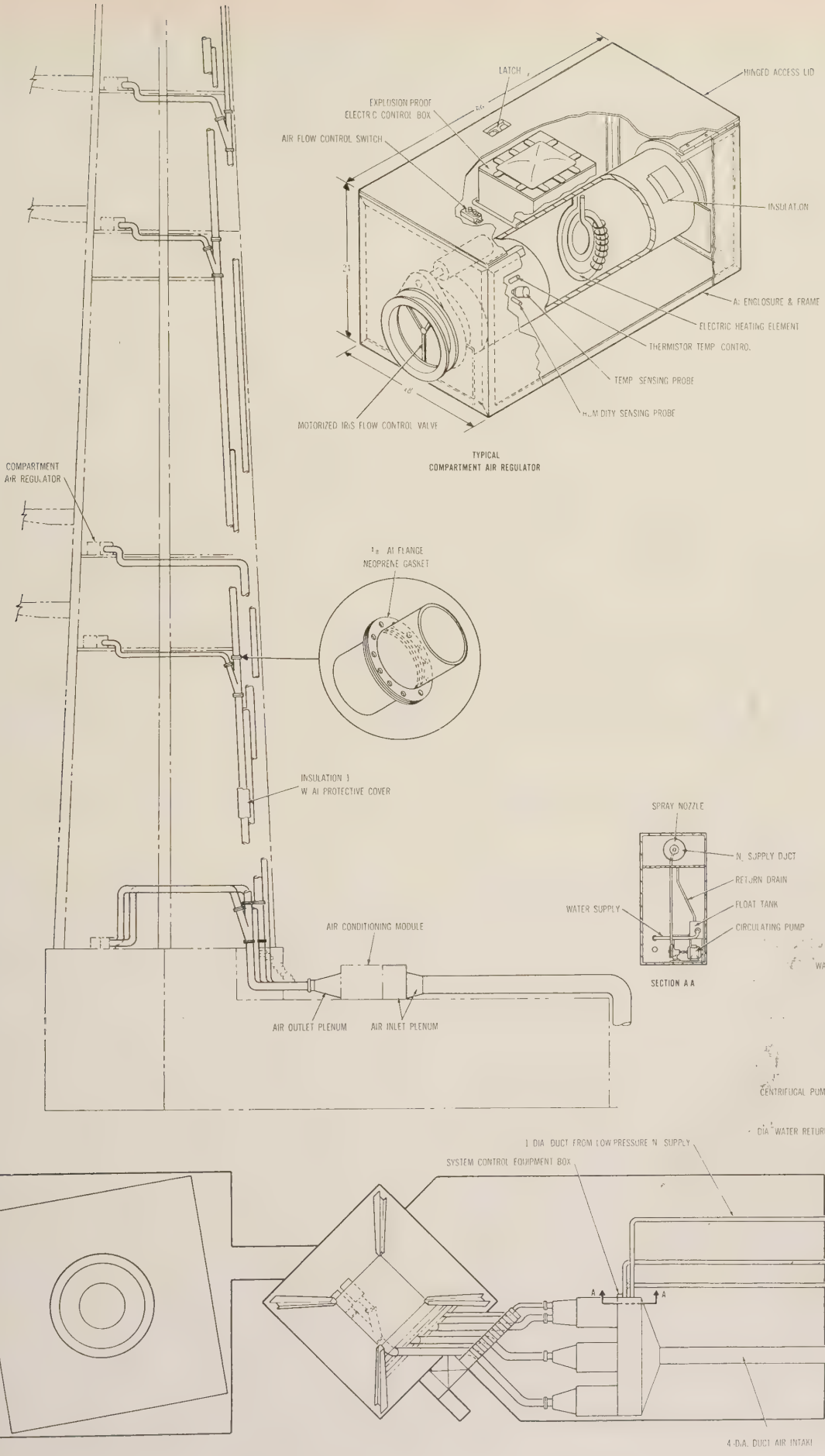
Many support proposals for advanced boosters are beginning to emphasize water transportation. What's needed here is a thorough study of the economics of the problem. What's really cheapest, a barge, or a renovated ship from the mothball fleet, or some odd craft like a catamaran? Of course, there are technical questions, too, not the least of which concern the effects of salt-water corrosion.

## Flow rates will have to be raised

As liquid boosters increase in size, their transfer systems will become more complex. If their countdowns aren't to be intolerably slow, flow rates will have to be raised. To cool the flame deflector of a typical advanced booster system, you may have to pump 100,000 gpm of water, using something like 20,000-30,000 hp.

In static testing, it's been suggested, this problem might be eliminated by a combination of water transport and an offshore test site. An underwater foundation would be built and the barge carrying the booster towed into position over it. Compartments in the barge would then be flooded to sink the barge onto the foundation for the test. After the test, the barge would be pumped out and refloated. For the propellants, though, high-flow-rate pumping systems will be needed in any case. Fur-

**AIR CONDITIONING system for Apollo is in the early design stage at Telecomputing's Advanced Structures Division. Air is supplied from modules at 52 in. $H_2O$. Nitrogen comes in through a 12-in.-diameter duct at 150 psi and goes through a valve that drops it to six inches $H_2O$. Eleven compartment air ducts branch off from four main ducts. Duct diameters vary from eight to eighteen inches. The air ducts are insulated by one-inch fiberglass covered with rigidized aluminum.**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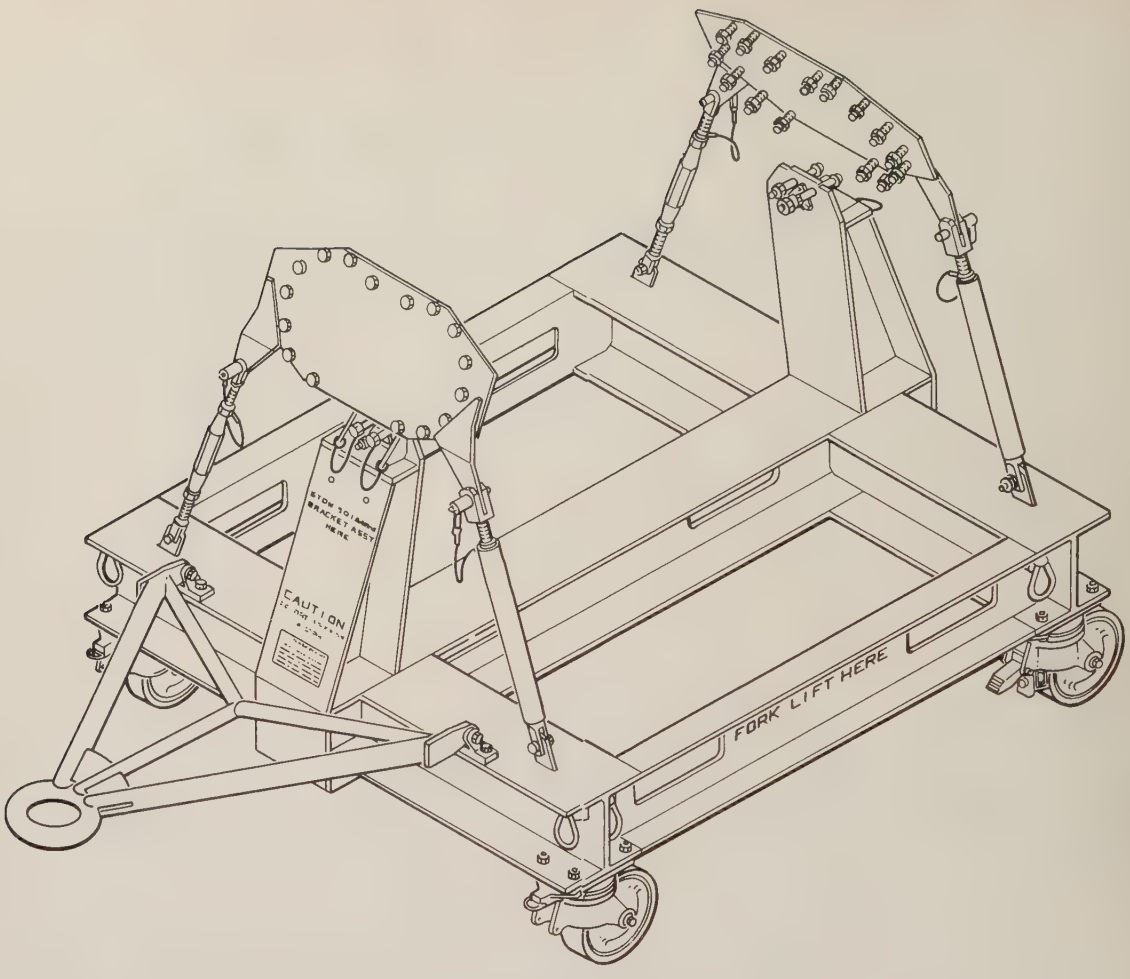



**TURBOPUMP HANDLER** for Rocketdyne's 1,500,000-lb-thrust F-1 engine is used as both work stand and transport dolly.

thermore, a great deal of test equipment will be required to check out these huge transfer systems. Most of this test gear does not yet exist.

## Solids will have simpler equipment

Although they pose the worst weight problems, solid boosters, it's widely agreed, generally will have simpler support equipment than the liquids. A prime goal is to design standard handling equipment that can be used in all phases from production to launch. As for liquid rockets, the idea is to keep using the fixture on which the engine—or a segment, in the case of solids—is assembled. This fixture would form part of the depressed section of a special rail freight car or a highway transporter, onto which it would be slid from a transfer dolly (which in turn would be used again at the launch site).

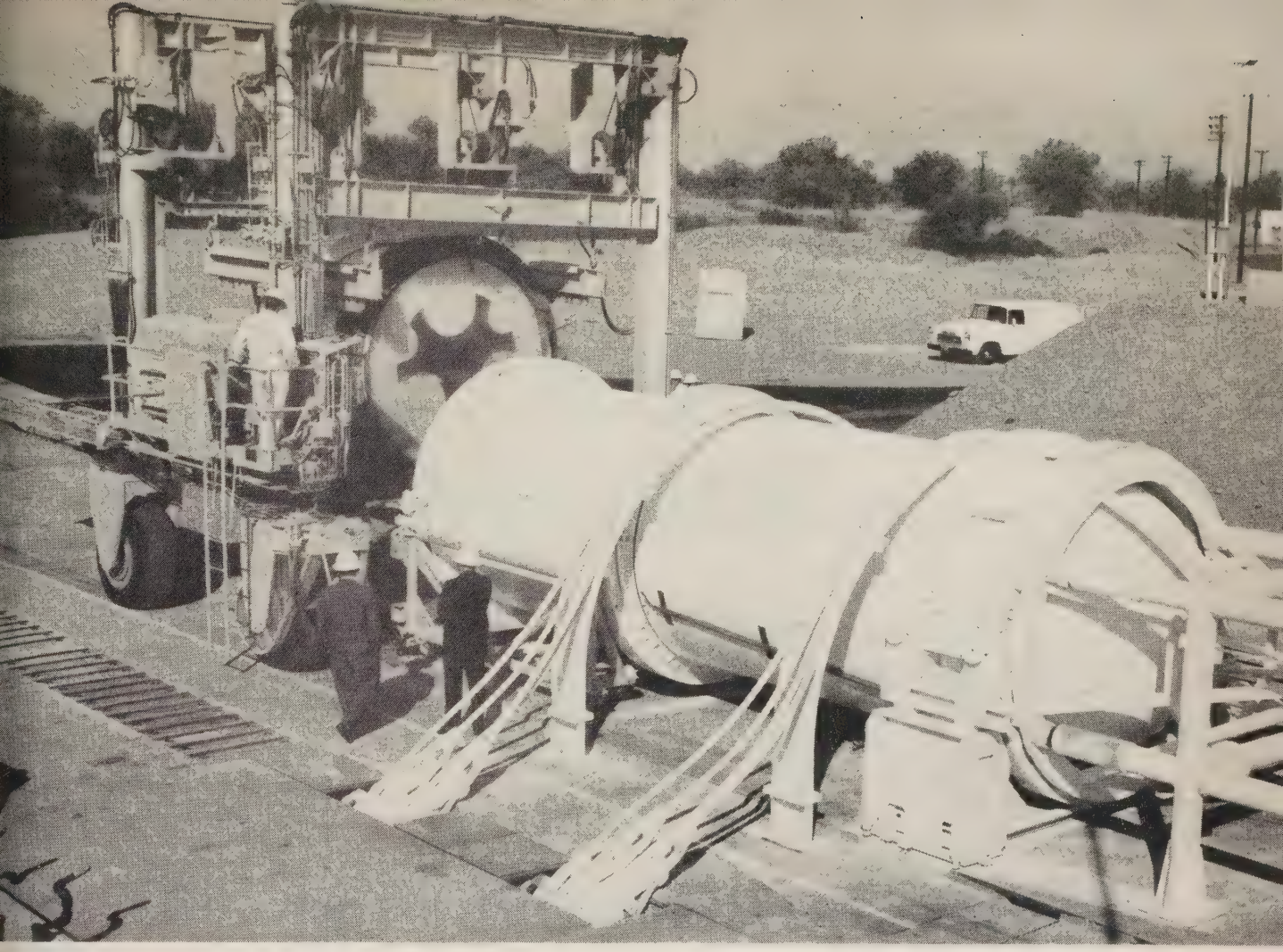
For the assembly of segmented solids, precise indexing and alignment instrumentation is needed. The closure nozzle must be located on the platform, and on clustered boosters the structural connecting link must be accurately positioned. The assembly of the segments to one another calls for a crane with coarse as well as fine alignment. Particularly critical is the alignment of the nozzle with the center of the motor and the indexing of the segments to one another.

Some of the requirements for advanced booster support are reflected in the air-conditioning system being built for the Apollo complex by Telecomputing's Advanced Structures Division. Some 225 tons of refrigeration are needed, corresponding to about 2,000,000 btu of heat.

The system supplies both air and nitrogen. Its main units—three identical 75-ton modules—must be located some 1000 ft from the pad to make sure that fresh air is provided—the air around the booster will be contaminated. Before fueling, air will be provided to all parts of the vehicle. Once fueling has started, air will be supplied only to the manned section and nitrogen to the other sections.

## Basic frame material is 1010 steel

The basic support equipment for Rocketdyne's 1,500,000-lb-thrust F-1 liquid rocket includes an engine handler, a turbopump handler, an electric and pneumatic checkout cart, and an RP pump unit. The handler is of tubular and I-beam construction, 18 ft wide, and 21 ft long. As on most of the F-1 handling equipment, the basic frame material is 1010 steel, but highly stressed areas like arms and ball joints are made of 4130. The handler supports the engine in the horizontal position for transport. It includes a hoisting adapter for raising the engine to the vertical position with the help of two



**FOURTH AND LAST** segment of an Aerojet 500,000-lb-thrust test motor — called "the world's largest and most powerful solid" — is lowered into place by its straddle carrier, which is also used to transport segments.

cranes. The turbopump handler is a good example of special handling equipment that wasn't needed at all for smaller engines. It is used for work on the engine and as a transport dolly.

## Checkout with standardized modules

The electric-pneumatic checkout cart uses standardized modules. In the past, Rocketdyne engineers note, it was the practice to design single panels with several supplies for various leak and functional booster system tests. As programs changed or new engine requirements had to be met, the panel either had to be reworked or a new unit had to be designed. Rocketdyne decided to go to small modules covering different ranges that could be used over and over in different combinations. Its approach saved money despite the variety of modules because the basic design was standardized and the same tooling could be used throughout. Component reliability increased as a result of the repeated use of the same units on a series of programs.

Formerly, you might have had a panel with pneumatic check ranges of from zero to 60 and 100 to 500 psi. If a new engine required 0-60 and 500-1000 psi, you could use only half the panel. Rocketdyne avoids this embarrassment by designing modules covering small increments from zero up to 3000 psi and suitable for a variety of systems. (There are "clean" panels for lox, for instance, and "dirty" ones for fuel.)

The F-1 hydraulic RP pump actually boot-straps the engine during firing. At first it will have to provide 20 gpm at 2000 and 4000 psi, but this requirement will be doubled and perhaps tripled as advanced versions of the engine come along. Rocketdyne reports that, although up to now there is no off-the-shelf unit that can pump RP with its high lubricity, a Denison constant-volume-density pump with a wobble plate has given excellent results.

## Straddle carrier could take 80 tons

Typical of current handling hardware for segmented solid-propellant engines is the straddle carrier developed by Aerojet-General. It is used to move the solid's segments to the test stand, to weigh them (with electric load cells), to position them in their roll, pitch, and yaw axes, and to hold them together while they are attached to each other.

This carrier is 18 ft wide, 25 ft high, and has a wheel base adjustable from 10 to 20 ft. Its prime mover is a water-cooled 200-hp engine driving a two-stage, 3000-psi, 75-gpm hydraulic pump. Its present rating for transporting and positioning is 40 tons, but it can be modified to take an 80-ton load.

# Space and Lunar Support

- *Miniature spacecraft for orbital repairs*
- *Unvented space propellant storage systems*
- *Wheels better than tracks for moonmobiles*

**by Octave Romaine,** Associate Editor

SUPPORT IS SUPPORT, you might say. But that doesn't mean that support in space, on the moon, or on a planet is anything like an extension of conventional GSE. It is basically different chiefly because it *must* be integrated from the beginning into the system design and the mission planning and preparation.

In-flight spacecraft support is either internal or external. The former includes the maintenance, repair, test, and checkout of vehicle systems and the bionic evaluation of the crew. The latter includes the servicing and repair of a vehicle's structure and exterior equipment, the maintenance of unmanned satellites, the assembly of space stations, the storage and transfer of propellants in space, and some aspects of rescue, retrieval, and ferry operations.

The in-flight support of unmanned satellites will have to be automatic or controlled from the ground until we have the external support techniques and equipment to accomplish some of the maintenance and repair work on these satellites in much the same way as the assembly of a space station. Aboard a manned satellite, the division of in-flight support between automatic equipment and the crew will depend largely on the mission. The one man in a Mercury or Dyna-Soar vehicle will have his hands full just controlling his craft and operating the communications and observation equipment. As the flights to be made by such vehicles will be short—from a few hours up to one day—the reliability problem could be worse, but all critical systems nevertheless will have to be redundant, with automatic monitoring and switching. The pilot will probably be responsible for monitoring only the systems he is actually operating.

Even on multi-manned vehicles flying longer missions, like Apollo or space stations in permanent orbit, there obviously will have to be automatic checking to forestall catastrophic failures. A properly trained crew could, however, perform many of the functions now entrusted to automatic checkout equipment in the ground support of missiles and satellites.

Electronics will make up the major part of the equipment to be serviced by space crews. High component density and micromodule designs in most cases will eliminate all repair and replacement on the component level. Repairs as a rule will consist of the physical replacement of a chassis or sub-chassis or the switching of units out of and into circuits. Computers and CRT-devices will be available to the crew as diagnostic tools.

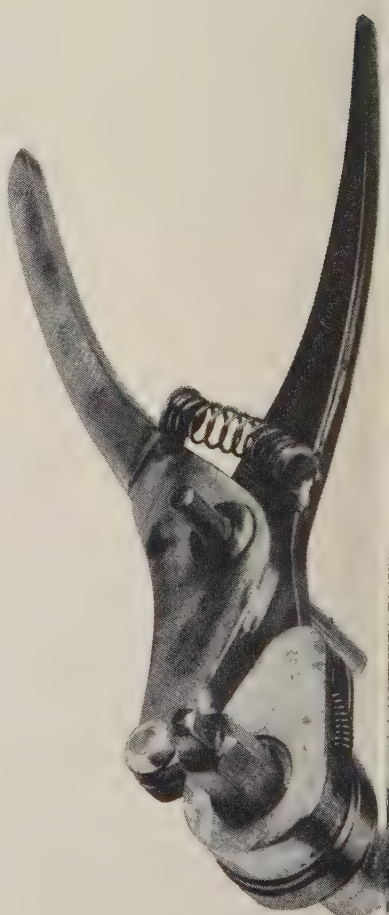


FIGURE 1: "Plench" gives a rota motion to a socket wrench or scre driver by virtue of the squeeze actic of the operator's hand. The pins pr truding from it fit into a socket f absorbing the torque reaction.

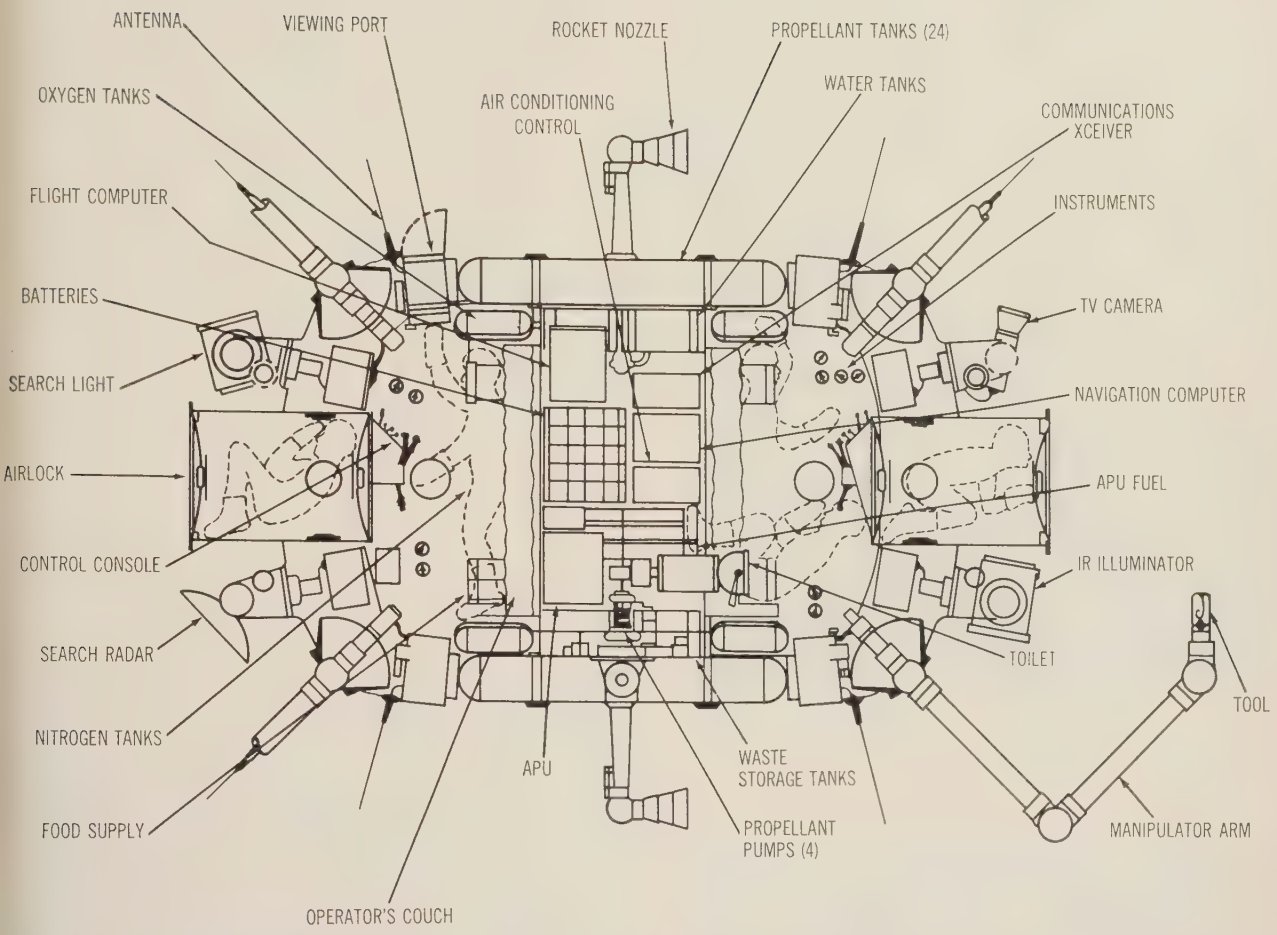



**FIGURE 2: Miniature spacecraft like the Lockheed "astrotug" appear to be better suited to external in-flight support than men walking around on the surface of spacecraft in bulky space suits.**

Anchor fittings will have to be provided at all locations where service work might have to be done, so that the space repairman can function efficiently in his weightless environment. Special tools for the assembly and removal of screws, nuts, and bolts will be required, as well as latching mechanisms with low-force, positive locking action for making and breaking multi-connectors and the like.

## Wrenching done by squeeze action

What a space crew's hand tools may look like is shown by the "plench" developed at Chance Vought's Astronautics Division (*Fig. 1*). This is a ratchet tool that is operated by squeeze action and can drive socket wrenches or screw-driver bits. A pin protruding from the face of the tool parallel to the axis of rotation fits into a socket next to the stud or screw-hole to absorb the torque reaction. Another possibility, at least for interior work, would be a motor-driven right-angle tool with an adjustable strap or arm that could be anchored to a convenient fixture to absorb the reaction force.

The space crew, of course, must be monitored just as constantly as their craft. In short-term orbiting vehicles, the crew is in a fixed position all or most of the time, which simplifies the problems of bionic instrumentation to sample essential physiological functions. For longer missions, a miniature telemetry system will be needed for each crewman to transmit the information from the various transponders to a central station. Information on heart beat and blood pressure, breathing rate and depth, skin resistance, electric activity of the brain, temperature, oxygen content of the arterial blood, and so on, will all have to be correlated automatically for the individual and also against the data for the other crew members. The instrumentation that the crewman will have attached to him in some way is already being developed, but the data needed to program a computer that will take all the bionic information and tell each crewman whether he should continue his duties, stop, go to sleep, or even order the abandonment of the entire mission still has to be amassed in extensive testing programs, both in simulators and on actual missions.

The science-fiction concept of a man in a close-fitting space suit clambering around on the outside of a spacecraft and flying through space under his own power doesn't hold up very well under sober examination. The man in the space suit would have all the requirements

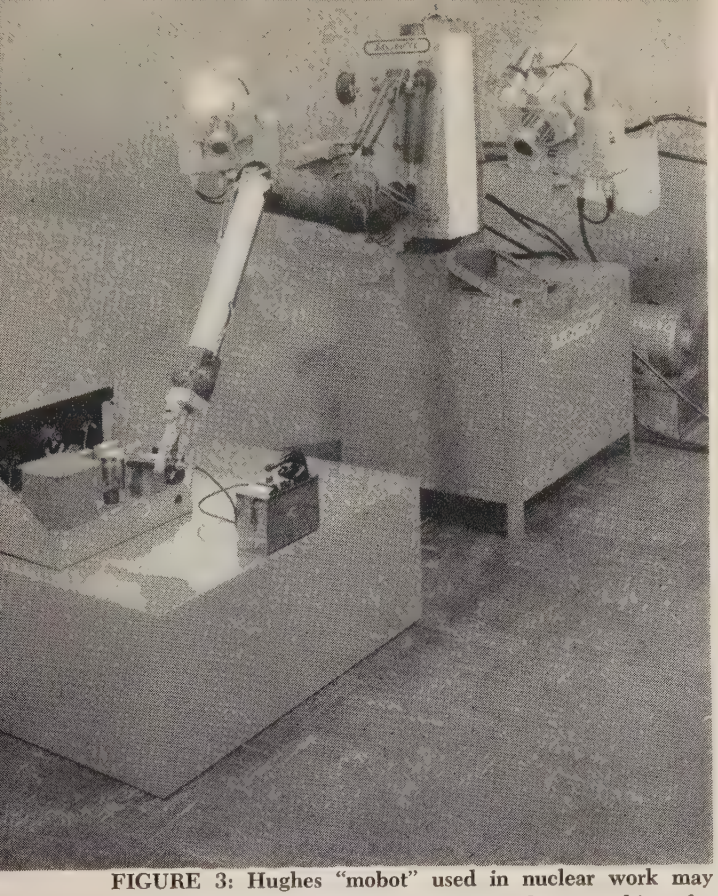


**FIGURE 3: Hughes "mobot" used in nuclear work may be the forerunner of a family of manipulator machines for in-flight and lunar support.**

of a man inside the spacecraft, with the possible exception of a food supply and body waste disposal. He would need a thermal control system, radiation and micrometeorite protection, an oxygen supply, and carbon dioxide disposal, a communication system, and some way of maintaining his orientation. Unless he is to be limited to moving from handhold to handhold or wears magnetized shoes and walks on the surface of a vehicle with a magnetic skin, he will need a very precisely controlled propulsion system and some means of navigating as well. His suit would have to have floodlights for work on the vehicle's dark side, and its viewing ports would have to have an automatic polarizing system to protect him from the direct glare of the sun. He would have to carry along all the tools that he would need, all of them securely fastened to his suit yet readily accessible. Finally he would need either a self-contained electric energy source or an umbilical connection to his spacecraft for the various systems included in his suit and for his power tools. Generally the suit would have to have foolproof puncture protection, since its small atmospheric volume and restricted oxygen supply would make even a minute puncture fatal.

## Weightlessness doesn't affect size

Providing all these requirements in a suit that isn't too bulky and stiff to let the wearer perform useful work will not be easy. Weightlessness won't make such a suit smaller, which means there'll be problems of storage and in maneuvering to get through airlocks.

Miniature space ships have naturally enough been proposed as alternatives to the personal space suit. Kramer and Bryers of Lockheed, have been working on the idea of an "astrotug", a work vehicle for a two-man crew (*Fig. 2*). The astrotug has a cylindrical living and working compartment, with an airlock at each end, that contains all the life-support equipment, food and supplies needed for extended space station assembly work. There is a throttlable propulsion system for maneuvering and instrumentation for navigation and detection, recognition, and rendezvous with space station components and other vehicles. Fuel is stowed in tanks on the outside of the vehicle, while accessory equipment is located between the inner and outer skins and in the center part of the compartment between the work stations.

Although designed for a minimum crew of two, the astrotug can accommodate four people and can serve as a ferry for crew transfer and supply. Men or equipment are transferred by coupling one of the airlocks to a matching one on another vehicle.

A set of four remotely controlled manipulator arms is provided at each end for the actual assembly and repair work. The manipulators can all be controlled from either work station. The controls consist of a scale model of each manipulator arm and hand in its proper relative position. Movement of the model arm by the operator is exactly repeated through a servo loop by the full-sized external arm. The model manipulators have feel to make very delicate operations possible. The arms will be powered by electric motors.

## Arms to hold tools, lights, cameras

Various tools, or hands, can be used on each manipulator arm. They are held in clips outside the tug, can be installed by any two other manipulators, and include gripping hands to grasp vehicles or parts, wrenches, screw-drivers, hammers, and any other special tools that might be needed. The arms can also move lights and TV cameras into position for close observation of the work being done.

The use of remotely controlled manipulator arms for support in space also has been extensively explored by John W. Clark, of Hughes Aircraft, who has proposed the use of unmanned "mobot" maintenance and repair vehicles (*Fig. 3*). Each of these would be equipped with a number of manipulator arms for specific tasks and would be controlled via cable from a command vehicle or via radio over longer ranges. Larger mobots could be used for assembly in space, and mobots for lunar exploration are another obvious possibility.

The mobot can perform rather complex operations, like replacing components and adjusting controls and the like. In nuclear work, mobot-type handling machines have successfully poured liquids, opened and closed doors, and operated small power tools. After a considerable learning period, an experienced mobot operator becomes completely unaware of the controls linking him to the machines and identifies himself with the mobot.

For full-scale external in-flight support, propellant storage is as important as assembly, refueling, and repair. Space storage of both liquid and solid propellants is largely a matter of thermal control. Solid propellants would be easier to transfer in a weightless environment, but actually their sensitivity to thermal cycling might make them less suitable.

Researchers at NASA's Marshall Space Flight Center have been studying the problems of storing liquid hydrogen in space. They have analyzed vented, or constant-pressure, storage, unvented, or constant-volume, storage, and a combination of the two, assuming an insulated storage tank (spherical or cylindrical with hemispheric ends) in a 300-mile circular orbit at 30 deg inclination.

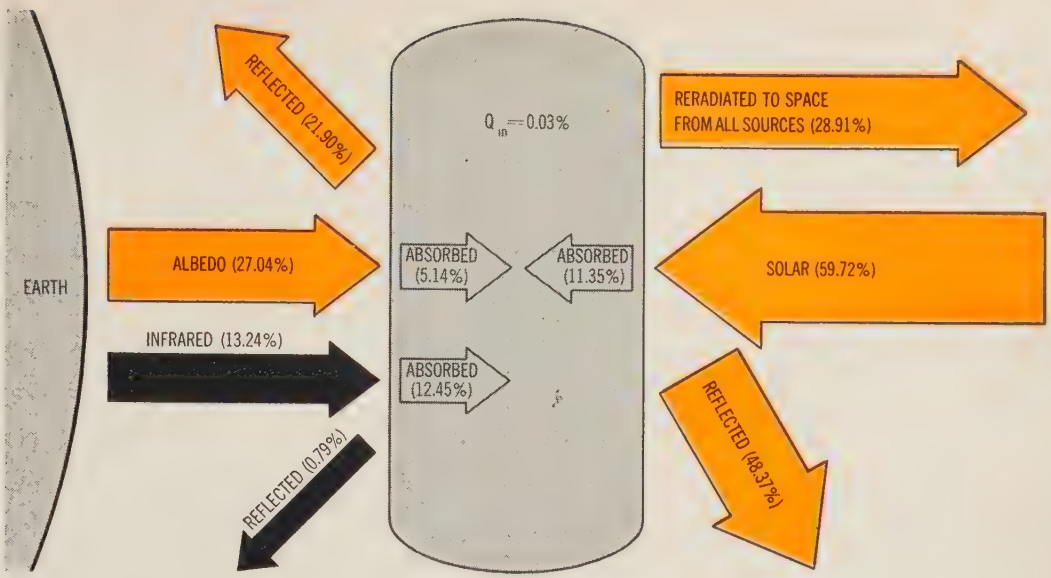



FIGURE 4: Heat balance for orbital propellant storage.

They further assumed that aerodynamic heating in this orbit as well as initial ullage would be negligible and that the propellant would be supercooled before being put into orbit.

The tank assumed by NASA is in sunlight at least 60 and at most 75 per cent of the time. In addition to the direct solar radiation, it is irradiated by the earth's albedo during about half of each orbit and exposed to the earth's infrared radiation (equaling about 18 per cent of the sun's radiation) throughout its orbit (*Fig. 4*). The infrared is the most troublesome form of radiation in this case, because materials and surfaces with low equilibrium skin temperatures for solar radiation and albedo are good infrared absorbers. However, there are materials available for extended orbital storage.

Since the thermal factors are the same for all orbital storage systems, selection becomes a matter of economics. At delivery costs into orbit of $500-$1000 per pound, cost per pound becomes the most important criterion. Since the fixed weight of vented and unvented systems can be considered equal, the storage weight penalty can be used as the basis of comparison. NASA found that sub-cooled, unvented storage seems to be most economical (*Fig. 5*). Of course, the GSE for sub-cooling cryogenic propellants in quantity and holding them until launch still has to be developed.

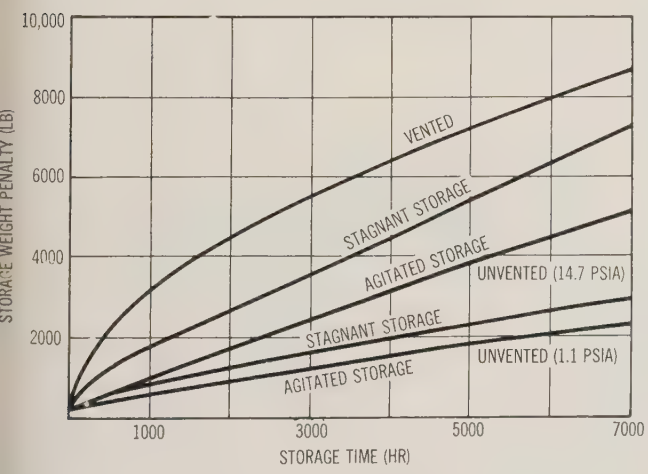



FIGURE 5: Weight penalties for vented and unvented orbital storage of liquid hydrogen, assuming 40,000 lb of propellant are to be available at the end of storage and the maximum pressure for unvented storage is 35 psia. For unvented storage, two values of initial pressure are assumed.

Liquid-propellant transfer in space is no less of a problem than storage. Bladder expulsion will not be feasible until we have flexible materials that can take cryogenic temperatures. Even then, it will probably be limited to small tanks. Liquids can be transferred in a gravitationless environment by imparting a spin to the tank and using centrifugal force to guide the contents through spiral baffles to collecting manifolds, from which it can be pumped to the receiving vehicle. The spin rate would have to be quite high.

Once we've reached the moon, support equipment will be used for the exploration of the lunar surface and to guide freight and personnel vehicles to assembly points. When fixed bases have been built, most of the terrestrial counterparts of GSE will be required, in addition to large-scale life support systems (which will include food-growing apparatus, and means of extracting oxygen and water from the moon's minerals).

## More weight can be carried on moon

The lunar environment, although in some respects fully as inimical as that of space, has the advantage of a gravitational field one-sixth as strong as that of the earth. This is enough for frictional drives, while providing a large weight-carrying bonus.

As pneumatic devices and most non-metallic, flexible materials are useless on the moon's surface, the choice will lie between tracks and solid wheels. The surface on which the "moonmobile" will travel in the level areas is believed to consist of a layer of volcanic ash and other debris and meteoric material several inches deep. Since there is no wind to cause drifting, this should be a remarkably even surface by terrestrial standards.

The wheel seems to have several advantages over the endlss track. Its simplicity probably is its gratest asset. In the ultra-hard lunar vacuum (almost as high as that of space and much higher than any that can be achieved

on earth) rubbing metallic surfaces, whether lubricated or not, will cause troubles. The multiplicity of joints and bearings in the usual crawler track and suspension threatens to create enough difficulties to offset the advantages of being able to cross crevasses more easily.

Thermal control problems are even trickier for lunar vehicles than for spacecraft. The orientation of the moonmobile relative to the sun will not be constant over long periods, as in the case of orbiting vehicles, and the shadow side will not be radiating to the limitless heat sink of space. The underside of the lunar vehicle will be radiating to a poorly conducting surface at close range, and most of the radiation will be reflected right back. At the same time, other vehicle surfaces in the shadow will be at —250 deg F.

### Solar storms pose extra hazard

Man on the moon will have to look out for solar storms. He will be protected against the average incident radiation by his moonsuit, but a warning system will be needed to get him back in time to his spacecraft or some other substantial shelter when a blast of radiation from a solar storm is on the way.

This danger could be avoided by carrying out manned lunar exploration at night. A. B. Hazard, of Space-General, has proposed this mode of operation for a 12-man lunar expedition using wheeled moonmobiles. These are four-wheeled carts, whose wheels have flat-cleated rims and are individually powered by electric motors (*Fig. 6*). The electric power is provided by a thermodynamic engine or fuel cells burning hydrogen and oxygen, so that the same supply could be used for both power and life support. The motors are geared down. Hazard's moonmobile does 5-10 mph, so you could cover 500 miles in a lunar night.

### Suit to live in for two weeks

Each explorer would wear a moonsuit that is integrated with his moonmobile and in which he could live continuously for 10 days to two weeks. The suit's oversize body section lets the occupant perform all normal body functions. Equipment is provided inside the suit for heating food, for communications, and for controlling the moonmobile. If he wants to sleep, the lunar explorer fits the pins on the sides of his suit into trunnions at either end of his moonmobile and tilts himself backwards. The suit's interior is sufficiently padded to make him reasonably comfortable in the low lunar gravity. Normally the explorer will also ride with the suit supported in the trunnions (in an erect position). His hands will be inside the suit's body section while he operates the moonmobile.

For any extended stay on the moon, living and working quarters will probably have to be set up other than the spacecraft in which the explorers have landed. Volcanic bubbles and tunnels have been suggested as possible shelters; if they are used, they will have to be made airtight, and life-support equipment will have to be set up. Whatever housing is used, it will be sunk below the moon's surface, so that a covering of moon soil will provide protection against radiation and meteoric particles.

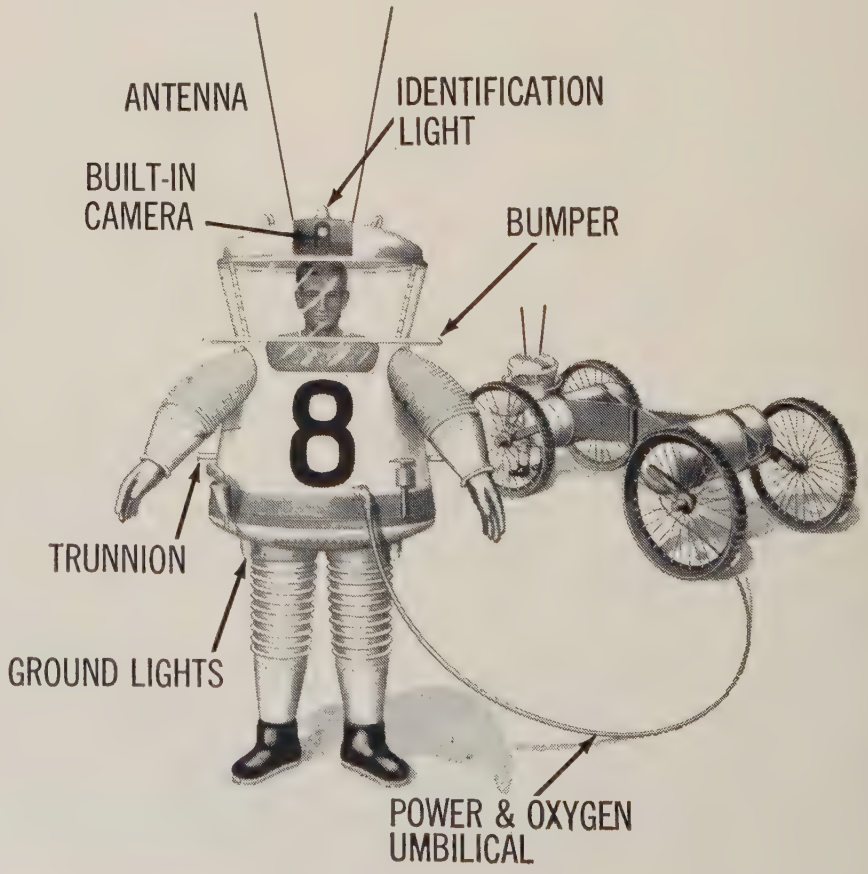



**FIGURE 6: Preliminary design of Space-General moon suit and moonmobile and a model of the suit. The estimated "lunar" suit weights are: man, 30 lb; basic suit, 10 lb; battery, four pounds; two-week food supply, five pounds; two-hour oxygen supply, four pounds; communications equipment, two pounds; reading matter and miscellaneous equipment, two pounds. A larger oxygen supply and water would be carried on the moonmobile. On earth, everything would weigh six times more, of course. The big number on the suit is for identification. (Not shown: Scorecard, without which you can't tell the moon players.)**

# Automatic Checkout

- *Design aims and methods begin to take shape*
- *Less automation and duplication, more reliability*
- *Automatic diagnostic testing is prime goal*

**by James Holahan,** Electronics Editor

AFTER FIVE YEARS of wholesale misunderstanding and confusion, the design picture in automatic checkout has finally begun to take shape. There is still much groping, but there is also increasing agreement on what should be done and how. Furthermore, the emphasis now is decidedly on getting more value per equipment dollar—quite a change from recent years, during which fantastic sums were spent on equipment that rarely came up to scratch. Automation for the sake of automation was rampant. Many designs were meant to be so foolproof they could be operated by a nitwit, with the result that they got so complicated they didn't work at all or couldn't be maintained. On the military side, there was a combination of vague specs and a lack of people and facilities to evaluate automatic checkout equipment (ACE), and often equipment was bought that wasn't really needed.

The great mistake of the past, it appears, lay in the frantic rush to build automatic checkout equipment (ACE) without first finding adequate answers to such basic questions as, What has to be tested? When must it be tested? How can it be tested best? What are the overall design constraints (cost, checking speed, repair rate, available space, environments, etc.)?

Over the last year, determined attempts have been made to answer these questions. All three services are doing a lot of soul-searching in hopes of coming up with clear-cut data on ACE design criteria, applications, and requirements, and some of the major ACE manufacturers have been following suit.

For USAF, the major studies of ACE have been done by Rand, which recently completed Project ACE. Started in 1958, this study took some ten man-years of research and was designed to develop concepts that would help make ACE designs more effective.

### Two functions for checkout gear

Weapon system checkout equipment is suited to two functions, the Rand study group says:

- Confidence testing to determine whether a weapon is "mission-worthy;"
- Diagnostic maintenance checking to isolate malfunctions, usually done after a confidence check has shown that a weapon is not "mission-worthy."

*Automatic* checkout, the Rand group asserts, appears to be the answer to many, but not all, such problems as high test speed, remote operation, complex diagnosis, difficult testing (e.g., closed-loop testing and dynamic testing with simultaneous monitoring of input and out-

put), in-flight testing, and test manpower shortages (especially at high skill levels).

Up to now, the Rand group reports, we've been able to automate confidence checkers but not the diagnostic ones. The problem with diagnostic ACE appears to be that the designer just hasn't been able to anticipate all the modes of failure in the prime equipment. The Rand group sees a trend to combine the two types of ACE, but considers that unwise. It believes it would be better to keep the confidence checker simple, since it is used for the bulk of checks and therefore more likely to be operated by personnel of relatively low skill. The only time you need a diagnostic function integrated with confidence checker is when the reliability of the prime equipment is low, Rand says, and this is a problem to be solved by the design of the prime equipment rather than by the test equipment.

Fortunately, none of the many serious problems in ACE design appears to be insurmountable. One of the worst problem areas is the "interface" between prime system and ACE design groups.

ACE designers, for instance, are constantly griping that they never are given enough points where they need them. The prime equipment designers, on the other hand, complain that the ACE isn't flexible enough to keep up with the modifications of the prime system.

More flexible ACE also is needed to compensate for complementing drifts within prime equipment. Most of today's checkout gear inflexibly rejects equipment when a part or circuit has drifted out of tolerance, even though this drift may be made up for by compensating drift in another part or circuit

## ACE hasn't been "sold" to its users

Another area in which ACE design has missed the boat is human factors. After a recent survey, Dunlap & Associates concluded that ACE hadn't been properly "sold" to the using organizations. Military technicians were told either directly or by implication that, with ACE, any idiot could maintain complex gear by just pushing buttons and looking at the red and green lights. The technicians were not at all cheered, and took out much of their resentment on the new test equipment. They were quick to condemn it when it faltered (which was often) and to go back to the older, non-automatic methods. The technician, Dunlap recommended by way of remedy, should be given a greater role in the test-diagnosis loop, doing

## USAF ACE Study Programs*

### Test Equipment Application Study Program (Adept)

**Contractor:** Nortronics

A recently completed study to set up specs for Adept (AF Depot Equipment Performance Tester) and determine the feasibility of computer-controlled automatic test equipment. The specs were to include building-block and plug-in-module design concepts and define the requirements for a unit for automatic diagnostic checkout of USAF's AN/ALT-6B electronic countermeasures set, AN/ALT-59 and AN/APN 105 radar sets, AN/ARN-21 and AN/ARC-65 radio sets, AN/ARC-58, and AN/USM-26 frequency meter.

**Results:** (1) A spec for ACE capable of performing depot-level tests, including provisions for test control from a variety of units, among them Nortronics' Datico DAT-001 and a computer. (2) Design criteria and operating parameters for a computer-controlled automatic test system.

As estimated by Dayton (Ohio) AF Depot, the differences between manual and automatic testing for the electronic systems covered by the study are: ARC-58, 13½ hours vs 19 minutes; ARC-65, 17½ hours vs 27 minutes; ARN-21, 6¾ hours vs 70 minutes; ALT-6B, 2 hours vs 12 minutes. For the APN-59, 8½ hr vs 42 minutes were measured.

### Automatic Test Equipment Study for Dayton AF Depot

**Contractor:** General Dynamics/Electronics

Fifteen airborne units serviced at DAFB were studied to develop definite requirements, techniques, and application principles for depot use of ACE.

**Results:** Automatic testing is definitely feasible and desirable at the depot level. A building-block concept of testing was derived, and specs for stimulus generators covering all expected parameters are being worked out.

### Studies of the Effect of ACE on Field Reliability

**Contractor:** Arinc

The AN/ARC-27 radio set is being studied as a "guinea pig" in tactical aircraft under operating conditions at Lockbourne AFB, Ohio. Half of the sets are being tested automatically and the other half manually. **Results:** So far, a definite improvement in field reliability through the use of ACE. Early results indicate that equipment tested automatically has a 40-hour MTBF.

### Design Criteria for Automatic Test and Checkout Systems (ARDC Study Program SR-17530)

**Contractors:** Martin, Minneapolis-Honeywell, Motorola and Douglas (team), Norair

A program on which final reports have been submitted to, and are being evaluated by USAF and that was designed to:

- validate the requirements for test and checkout equipment for USAF weapons through '75;
- set up design criteria to insure the compatibility of test equipment with future weapon systems;
- determine the feasibility of standardized test equipment and methods;
- determine the feasibility of an integrated, multi-

* In part from C. J. Bloomer, "Automatic Checkout for AF Ground Support"; NYU, Project SETE.

the jobs that he can do better than a machine.

In many cases, the technicians even seemed to be fully justified in going back to manual methods—overall, these often proved still quicker and simpler. Although ACE spends relatively little time in actual testing, the picture changes when you add up the total time needed for roll-out, connection, test-equipment adjustment, testing, disconnect, and roll-back.

Today's ACE designs can do routine confidence testing and some can do a limited amount of troubleshooting, *if the prime equipment fails as predicted.* For the most part they are run by a punched-card or tape programer that controls a series of sequential, static, open-loop tests. Indicators vary from simple go-no-go to quantitative readings that may or may not be printed out. Some machines contain a certain amount of coarse test logic.

Most new ACE proposals are similar in one aspect: they call for greater automation. Yet Rand's survey concluded that even at that time USAF's ACE suffered from trying to do too much automatically and that many of the functions it was designed for could far better be done manually.

Working under subcontract to Rand, Dunlap came to the same conclusions: "Unfortunately, this trend [to ACE] appears to be unsystematic. Efforts have sometimes been made to design as much automation as was possible into the test and checkout operations, with the consequence that, in some instances, the state of the engineering art apparently was pushed to its limits, if not exceeded."

### 100% automation said to be risky

After observing automatic testing at six operational military sites, Dunlap reported that "in nearly all cases, there was a wide gap between what ACE was supposed to accomplish in theory and what it actually accomplished in practice. . . . In view of the only partial success of existing ACE, the risks for the completely automated route appear to be too great. However, unless a good deal more research and design effort is directed at a more adequate utilization of those qualities of man which are superior to the machine's, there may well be no other option but to proceed along the present unsystematic approach toward complete automation."

Contrary to popular belief, the Rand study group thinks that test automation will not save manpower and will actually raise the skill requirements. However, it

purpose ACE unit or family;

- Analyze checkout cost vs increased weapon-system effectiveness.

**Results:** Martin announced that it has devised a "golden-cube" concept of checkout design and subsequently developed 27 checkout hardware designs for future weapon systems. The "golden cube" has three axes on which, for a given checkout requirement, the degrees of automation, "multipurposedness," and integration are entered. These entries define a point in the cube that, according to Martin, indicates the best design approach to meeting the requirement. (Comment from industry and private research groups on the golden cube: oversimplified and does not answer the big poser, How to determine the input parameters?) Martin also sees little need for a universal checker.

### Study of Versatile Automatic Test Equipment (Vate)

**Contractors:** Arma, Bendix and ITT (team), Hughes Aircraft, Lockheed, Sperry Gyroscope.

A program to determine concepts for versatile automatic test equipment for the automatic isolation of system failures in inertial-guidance subsystems to unit, module, and (if feasible) component levels. It is expected to lead to a spec for a test system for the Atlas, Titan, Hound Dog, Minuteman, and Skybolt IG systems. Fault analysis will be done by a computer-controlled system. The computer will have both permanent and temporary memory and a storage capacity of a million bits or more.

### Study of Automatic Checkout Techniques

**Contractor:** Battelle Memorial Institute

A study of the problems of automatic checkout of complex weapon systems that is expected to lead to new principles in ACE design and operation. Specifically it is intended to develop methods for:

- checking the operational status of equipment;
- isolating defective components;
- indicating the operational status of equipment to system control personnel;
- estimating the deterioration in performance at various degrees of malfunctions;
- automatically translating test program language into machine language;

In addition, the feasibility of using system equipment to check out man as a component of aerospace systems will be studied.

### Project ACE

**Contractor:** Rand

A study, begun in '58, partly subcontracted to Dunlap & Associates, and intended to develop concepts that will help to make ACE more effective.

**Results:** Reports have been published on "Automatic Checkout Equipment: Employment and Design Considerations," "Cost Implications of Automatic Test Equipment: A Suggested Procedural Approach," "Missile Prelaunch Confidence Checkout: Content and Equipment Design," "Search Rules for Automatic Fault Location," "Determining Checkout Intervals for Systems Subject to Random Failures," "Standardization of Automatic Test Equipment: A Preliminary Discussion," "Manpower Implications of Test Automation," "Operational Criteria for the Design of Missile Readiness Testing," and "An Omnibus of Briefing Papers on Analysis of Automatic Checkout Equipment and Aids to Its Design" and will soon be published on "The Role of Automatic Checkout Equipment in Air Force Data Systems" and "Human Factors in Automatic Checkout Equipment: An Annotated Bibliography."

see ACE as a definite time saver and as particularly useful when quick checks must be made for rapid turn-around or to determine system readiness. It also considers automatic testing extremely useful when a low MTBF calls for short operating periods for testing.

### Maintenance men distrust ACE

Though it's axiomatic that checkout gear should be at least as reliable as the equipment under test, the Dunlap survey shows that in practice it often isn't. Maintenance men distrust ACE so much that, if a test shows a "no-go", their first impulse often is to check the ACE for a fault before they look at the unit under test. Dunlap reports cases in which ACE failed to reject out-of-tolerance equipment, including itself, and points out that, in some instances, field maintenance ACE passed equipment that flight-line ACE (on the same airfield) rejected. (Dunlap suggests that tolerances should grow wider as maintenance approaches the flight line.)

Ideally, ACE is designed with foolproof self-check and verification features. Apparently, however, it's just as hard to make complex electronics reliable in ACE as in other systems. One of the major causes of ACE unreliability as usual lies in our inability to predict all the many ways in which an ACE system itself can fail.

Another problem of current ACE is there are a great many different designs that all do virtually the same thing. Complete standardization has been found wanting (as in Nortronics' Datico program for testing seven Army missiles), but there are other, less vigorous approaches to standardization that look promising.

USAF's GJQ-9 standard programer-comparator designed by Bendix Eclipse-Pioneer for the Douglas Skybolt, is a case in point. It was dismissed as unworkable two years ago by many in the field, but just as many are admitting now that maybe it wasn't such a bad idea after all. Concepts similar to the one underlying the GJQ-9 are being used by Autonetics in the ACE for the NAA A3J's electronics and by Minneapolis-Honeywell (in its ZG-897 tester for the McDonnell F-101B). Modular building-block design as a solution for the problem of duplication is being pushed by the Army, RCA, and several others, and the Air Force also shows a tendency in this direction.

To avoid duplication in computer-controlled systems, several of these are designed to use off-the-shelf, commercial general-purpose machines. Packard-Bell has in-

## ACE Design Alternatives[1]

### Internal Programing[2]

- Can use quantitative test results to detect and isolate faults.
- Can solve more difficult problems, use more complex test results, and is faster, since a completely internally programed system generally will have a digital computer.
- Can operate two or more tests or two or more systems simultaneously.

### External Programing

Lower purchase price, less complex, and uses smaller equipment.

■ ■ ■

### Open-Loop Testing

- Is less direct and more equivocal.
- Can pinpoint trouble.
- Requires test equipment of greater accuracy.
- Is better suited to systems that do not involve control or regulation functions.
- Tends to be more reliable.
- Gives good quantitative information.
- Control functions are relatively slow.
- Improvement by automation is limited by the system's dynamic response characteristics.

### Closed-Loop Testing

- Directly reflects the system's condition.
- Tends to be unstable; is more insensitive and therefore tends to let internal drift go undetected.
- Can simulate the actual dynamic operation of the prime system when used with an auxiliary analog computer.
- Gives rapid indication of system readiness.
- Not good for diagnostic tests.
- Usually requires more maintenance.
- Excellent for high-speed turn-around checks.

■ ■ ■

### Static Testing

Requires simpler programer and lends itself to manual control.

### Dynamic Testing

- Could require a very sophisticated control and result-interpretation mechanism if the data input is high.
- Necessary when the system under test has or controls a dynamic phenomenon (e.g., a computer performing time-varying operations on input signals).
- Tends to cause more failures in prime equipment, which is being tested under greater environmental stresses.

■ ■ ■

### Digital Measurement

- Goes with multiple static, closed-loop samplings.
- Requires analog-digital converters.
- More attractive for complex system tests.
- Accuracy can drop catastrophically.
- Has logic for failure diagnosis.
- Makes it easier to change programs.
- Normally operates sequentially, therefore difficult to use for real-time measurements.

(1) Derived from Firstman, Kamins, Voosen, "Automatic Checkout Equipment: Employment and Design Considerations." (2) The method of programing, or control, tends to determine the automaticity of checkout equipment. External programing generally uses magnetic or punched paper tape, punched cards, or patchboards; internal programing uses magnetic drums, cores, etc., for program storage.

cluded its small PB250 general-purpose computer in its own, commercially available ACE and in design for Sereb in France. RCA will use its own small 110 general-purpose digital computer in the Saturn countdown checkout gear it is building for NASA.

Diagnostic checking and our failure so far to automate very much of it perhaps offer the greatest opportunities for improvement in ACE design. Actually, many engineers believe that what we really need is new methods of measurement. They point out that, despite our rush to automate, we still use the very measurement methods traditionally used in manual testing.

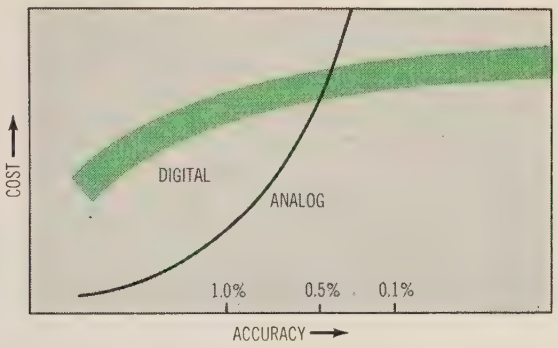
## Waveform analysis studied for ACE

Audiotronics, of North Hollywood, Calif., has designed a checkout system based on the measurement of circuit reactance to diagnose malfunctions. Nortronics and others are studying the possibilities of building ACE around waveform analysis, which would reduce the number of input stimuli and test point requirements. In computer-controlled ACE, the waveform could be converted to numerical form and correlated point to point with a known waveshape.

In the next-generation ACE designed for diagnostic testing, the digital computer will play a dominant role. Five ACE systems using digital computers are already being offered as operational hardware, though none has yet become part of a weapon system: Hughes Aircraft's D-Pat (*Fig. 1*), Lockheed's Acre, Packard-Bell's SE-1000, RCA's advanced DEE, and Maids, designed at the Army's Frankfort Arsenal.

Acre originally was developed for use on Polaris submarines, on submarine tenders, and on the factory production line, but its ultra-complexity forced the Navy to go to a simpler system for shipboard use. It is being used at Lockheed on the Polaris production line and may be used on shipboard later on.

Maids is perhaps the most radical design concept in the entire ACE field. It uses a general-purpose digital computer that stores the mathematical relationships between the elements of each circuit under test and measures the response to very small, known stimuli on the system and compares it with the precalculated correct effect. Where there is a discrepancy, Maids goes into a circuit probing operation using the same network-analysis principles as did the response evaluation to trace the malfunction down to a piece-part.




- Is more precise.
- Is more flexible.
- Preferable if accuracies better than 0.5 per cent are required.
- Adaptable where the prime equipment includes a digital computer.
- Costs less at higher accuracies (see Graph).
- Is faster for general (open-loop) processing when a large quantity of data has to be sampled, though speed is a function of the required accuracy.

### Analog Measurement

- Better for dynamic closed-loop testing.
- Typically forces the operator to perform manually a function that a computer would do automatically in a digital system.
- Requires smaller equipment.
- Operates in real time.
- Has faster dynamic response.
- Accuracy drops "gracefully."
- Is easier to program.

■ ■ ■

### Qualitative Measurement

- Requires less equipment.
- Has lower purchase price and operating cost.
- Is more reliable.
- Requires lower operator skills.
- Is faster in confidence tests.

### Quantitative Measurement

- Unit under test can be adjusted to bring marginal operations within a specified tolerance.
- Operator usually must read and interpret displays.
- Desirable when test results are to be used for determining a system's capabilities and limitations.
- Yields more information for malfunction isolation.
- Gives rough malfunction indication for drift failures.
- May be able to determine a more beneficial operating mode for equipment under test (e.g., low readings may show that prime equipment cannot perform its normal mission but can still perform a less demanding mission).

■ ■ ■

### Integral or Internal Test Equipment

- Adds weight to prime equipment.
- Can be used more conveniently and quickly.
- Tends to add unreliability.
- Usually is less accurate.
- Can be used while vehicle is airborne.
- Does not require additional equipment to the extent that the controls and indicators of the prime equipment are used.
- Is less affected by vehicle modifications.
- Arrives at the same time as the prime equipment.
- Provides each vehicle with its own test equipment.
- Space and weight compromises usually have to be made.

### Auxiliary or External Test Equipment

- Requires long cabling and isolation devices.
- Generally is better suited to fault isolation.
- Can be built to perform considerably more analyses.
- Easier to use for dynamic resting.
- Reduces the overall weapon-system cost (though its purchase price is higher).

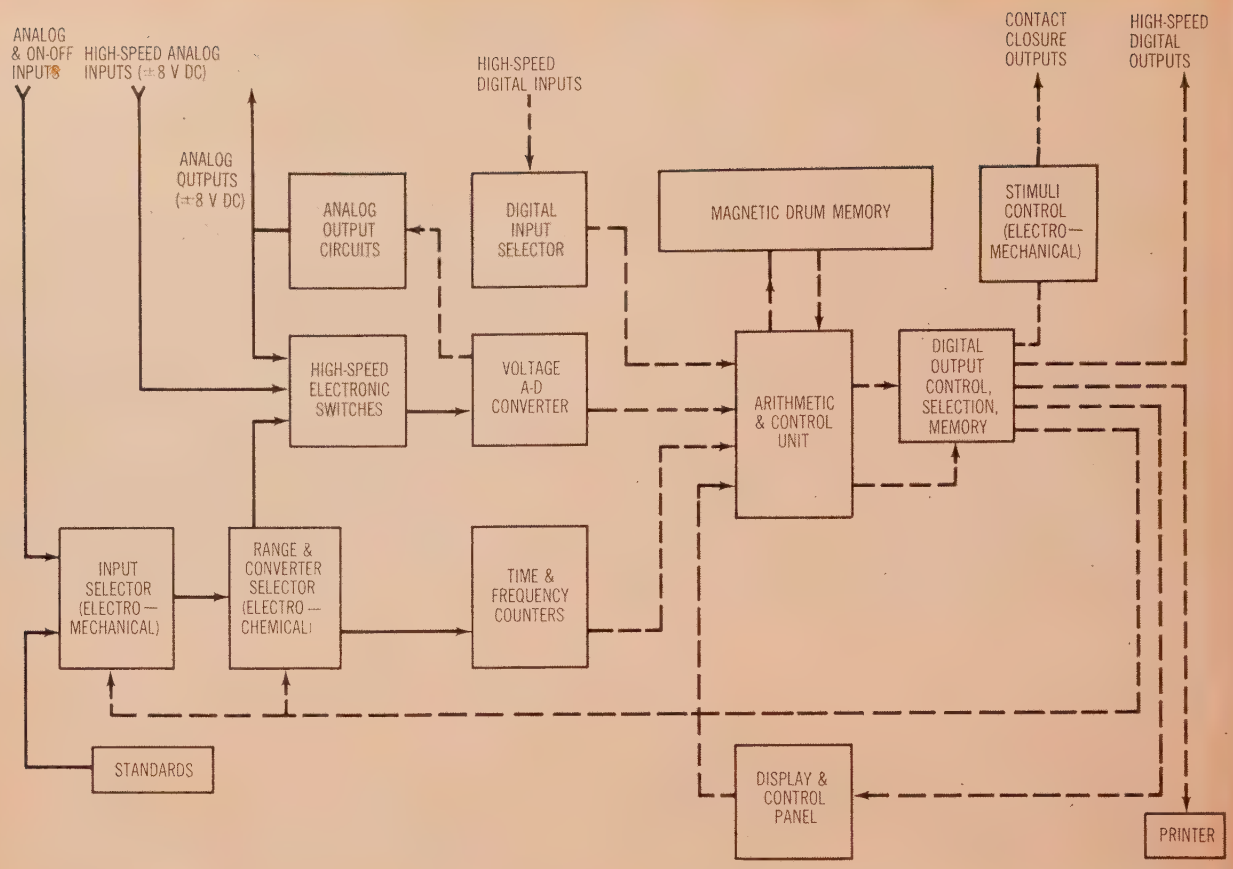



**FIGURE 1: D-Pat (for drum-programed automatic tester) was developed by Hughes Aircraft as a result of ACE studies for the Falcon air-to-air missile and is now offered commercially. A serial binary type with a 19-bit word length and a 250-kc clock rate, it has a memory capacity of 40,460 words, or about 900,000 bits, as well as a number of registers and temporary storage channels. It has 40 different program orders and is completely transistorized. Solid lines in this diagram show analog signals; dashed lines, digital or on-off signals.**

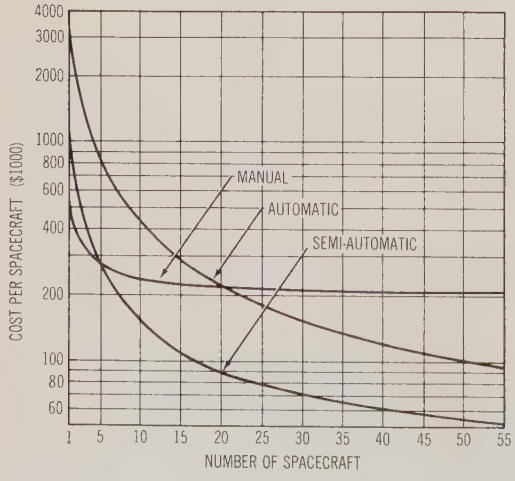



**FIGURE 2: Cost of spacecraft checkout for manual, semi-automatic, and automatic techniques.**

So far Maids can diagnose trouble in most commonly used electron-tube circuits and in several transistor circuits. The Army hopes to build its future ACE around three basic Maids for electronic, hydraulic, and automotive systems.

Automation has been almost completely absent in the checkout gear used on our first generation of spacecraft, for virtually every one of these vehicles has been unique and the checkout gear had to be flexible, so that it could be used on more than one system. In our second generation of spacecraft there already is a measure of duplication. Many programs—e.g., Ranger, Mariner, and Ogo—will use a series of similar and, in many respects, identical, vehicles. These similarities will undoubtedly make some form of ACE feasible. Studies by Space Technology Labs show that 5-6 identical vehicles will economically justify "semi-automatic" checkout (*Fig. 2*).

STL thinks that a spacecraft's normal telemetry link could be used while the vehicle is on the ground for relaying most of the test data to the test equipment. One of the main advantages it foresees for spacecraft ACE is that it would free many of the design engineers now needed during prelaunch operations. Easily operated and interpreted checkout gear would enable technicians to handle the prelaunch.

# Range Support

- *Real-time data processing is major problem*
- *Skilled personnel needed to design math methods*
- *Trend to non-synchronous computer processing*

**by Bernard Kovit,** Associate Electronics Editor

## ATLANTIC MISSILE RANGE

SPACE FLIGHT SUPPORT is at the forefront of planning at AMR (extending out from Cape Canaveral, Fla.), though in some cases the planning has not gone beyond the admission that the present state of the data acquisition and reduction art falls short of the new needs. AMR does, however, right now have the rudiments of its coming spacecraft support system in the Mercury network of trackers, telemetry, and communications, says C. R. Scott, Manager of data reduction for RCA Service, subcontractor to Pan Am for the collection and processing of AMR data.

AMR now uses two IBM 7090s—one for real-time computations in impact prediction and the other for post-flight data analysis. Using separate computers for these two functions is the latest thing, Scott told SPACE/AERONAUTICS. It insures that no problem is injected into the vital stream of real-time computations on which range safety depends and it makes for more efficient programing and scheduling of the myriad data to be processed in the aftermath of a flight. A third 7090 is scheduled for AMR.

Though the computer is undeniably at the heart of the AMR data processing complex, Scott explained, instrumentation raises the more pressing problems at present. Its accuracy, he believes, generally is the limiting factor in current range operations.

Among the huge and varied array of instrumentation at AMR (*Table I*), the major position-data gatherers are the Azusa and the FPS-16s. Only the 300-mile range FPS-16s can skin-track.

The bulk of the information that must be reduced for real-time response is obtained by radars, while most of the data for post-flight analysis is telemetered from beacon transponders in the vehicles. A growing array of optical telescopes and cameras is used (*Table II*), apparently to help solve the particularly difficult problem of getting accurate (and sufficient) data on the first 60,000 ft of the flight trajectory. Fixed ballistic cameras are the most precise monitors on the range and are used as references for all other data acquisition units. Six newly ordered 1600-lb, 600-mm, f/2 ballistic cameras from Nortronics will be used to collect down-range trajectory data with a reported accuracy of one in 200,000 (using multiple-site triangulation). The trend in all forms of trajectory instrumentation points to trackers that can be used with a wide variety of vehicles.

The impact prediction system at AMR quite clearly is the forerunner of the much more complex trajectory monitoring and supervision system needed for the coming spacecraft programs. It depends greatly on the accuracy of the range instrumentation and on the real-time data links (*Fig. 1*).

### Better instrumentation to come

Far-reaching improvements in instrumentation are in the offing. Chief among these will be the addition at the Cape of GE's Mistram, which is nearing completion. An X-band cw system for precise trajectory measurement, it will take its place alongside (rather than supplant) the Azusa and the FPS-16s. It will improve the accuracy of burnout velocity measurement from 2-3 fps to about 0.2 fps and spatial-position accuracy from the FPS-16s' optimum of about ±130 ft to ±30 ft, and it is further expected to shrink the circular error probability at splash to about 0.2 nm for a downrange distance of 8500-9000 miles.

Because of the ionization-sheath problems that make RF contact with the vehicle extremely difficult, AMR plans to install a second Mistram downrange at Eleuthera Island in the Bahamas to get a better look angle. This system will be fed acquisition transfer data either from the optical trackers or via data link from the FPS-16s. The Mistram's readout is digital and can be transmitted

directly to the 7090s at the Cape for processing.

Reliable real-time data transmission links are a particular headache at AMR. *Figure 2* shows an improved link developed by Lenkurt for use with Azusa in Nike-Zeus shots. Because of the problems of transmitting six words of tracking information over 6-7 miles of telephone lines—between the Azusa Mk II and the 7090 impact predictors—a new, "quaternary" modulation technique is used that roughly doubles the amount of data that can be transmitted over a given bandwidth. Codit (*co*mputer *di*rect to *t*elegraph), an extremely simple real-time data link, provides a direct electric connection between the 7090s and standard telegraph receivers anywhere in the world. It takes data from the real-time data channel at the Cape 7090 and reads it directly into telegraph lines in Baudot code.

Data-processing specialists point out that AMR's requirements for spacecraft operations will exceed the 36-bit word limit of the present system. Greater word lengths would cut down the number of computations needed to get the required precision (by adding decimal places to the measurement values) and so reduce the critical internal-speed difficulties of impact computations.

## Time standard to be supplemented

Accurate, synchronized timing at each range station is a critical requirement. AMR is planning to supplement the range timing standard (wvv) and studying a number of other solutions including local installations of rubidium-vapor or other frequency standards. Finally, it is hoped that communications satellites with 10-15-mc

**Table I: Electronic Instrumentation and Data Processing at AMR***

| Instrumentation | Form of Raw Data | Type of Data | Data Processing Reading Equipment | Output of Reading Equipment |
|---|---|---|---|---|
| Azusa Mk I | 729-format magnetic tape from IP 7090, Potter-format magnetic tape | digitized direction cosines & range | | |
| | dial film | photographs of servo output dials monitoring digitizing equipment | Recordak | information used by Data Reduction Unit for computing correction constants & editing; hand-punched IBM cards |
| | CEC oscillogram | function of equipment | hand-read on oscillogram reader | information used by Data Reduction Unit for calibration & correction constants & for monitoring equipment functions; hand-punched IBM cards |
| Azusa Mk II | Lenkurt-format magnetic tape | digitized direction cosines & range | | |
| | 729-format magnetic tape from Cape 7090, Potter-format magnetic tape | digitized direction cosine rates & range rates | | |
| | CEC oscillogram | function of equipment | hand-read on oscillogram reader | information used by Data Reduction Unit for calibration & correction constants & for monitoring equipment functions; hand-punched IBM cards |
| Dovap, Udop, Xtradop | magnetic tape | analog doppler frequencies representing range sum distance from transmitter to missile to receiver | | |
| FPS-16 | milgo magnetic tape | digitized (Gray-code & binary) azimuth & elevation angles & range | | IP 7090 via Milgo receiver |
| | magnetic tape, Universal field recorder | 729-format digitized azimuth, elevation & range (binary) | | |
| | 35-mm boresight film | photographs of orientation targets & missile in flight | Telecomputing theodolite film reader | digitized X-Y measurements of missile image with respect to film frame reference point on punched paper tape or IBM cards |
| | function & event recorders | | | information for monitoring equipment functions |
| Mod II radar | Giannini punched paper tape | azimuth & elevation angles & range vs time | | |
| | function record | function of equipment | hand-read | information for monitoring equipment functions |
| | 35-mm boresight film | film recording orientation targets & missile in flight | Telecomputing theodolite film reader<br>Recordak with grid | digitized X-Y measurements on punched paper tape or cards; hand-recorded measurements later punched into paper tape or cards |
| Telemetry | | analog internal engineering sequential information | | |
| Mils | Sanborn charts teletype message | arrival time | hand-read | time; hand-punched on IBM cards |

*The computer in all cases is either a DR 7090 or, for the magnetic-tape data from Azusa Mk I, the data from Azusa Mk II, and all except the Milgo magnetic-tape data from the FPS-16s, the impact prediction 7090.

bandwidths will become available for use by the range.

Satellite interrogation timing should prove a boon to the many shipboard and airborne tracking stations both in being and planned, as well as to outlying sites like the missile impact-location system (Mils). The latter consists of bottom-anchored five- or six-hydrophone arrays that determine the point of impact in the target area (*Fig. 3*).

One of the biggest problems in automatic range data processing is that AMR is having great trouble getting hold of enough scientist-mathematicians for the crucial task of designing the mathematical methods that will increase the data accuracy on the 7090s.

In spite of this, data-processing experts are assuming that programing skills will be upgraded in time to meet the increased data, accuracy, and reliability needs of spacecraft support. Consultants from GE, RCA, Space Technology Labs, and NASA are already working on a "best-estimate-of-trajectory" computing system that will look at all trajectory-data sources, weight them according to the best scientific estimates, and compute a trajectory of optimum accuracy. Programing lies at the heart of this technique, which does by math what can't be done with imperfect instrumentation.

Also promised for the future are local computers to share the job of data reduction with the battery of large-scale computers at the Cape. The FPQ-6 radars that will eventually supplant the FPS-16s reportedly will have built-in computers in their tracking servo loops. Belonging to the new breed of radars operating on computer control, they should greatly reduce problems like those of overhead-pass blind spots and acquisition.

| Peripheral Off-Line Computer Equipment | Output of Peripheral Off-Line Equipment | On-Line Computer Input Equipment |
|---|---|---|
| | | IBM 729 magnetic tape unit, FLAC-format IBM 727 magnetic tape unit |
| IBM card-to-magnetic-tape converter | 729-format magnetic tape | IBM 729 magnetic tape unit |
| | | IBM 729 magnetic tape unit |
| IBM card-to-magnetic-tape converter | 729-format magnetic tape | IBM 729 magnetic tape unit |
| Dare | IBM-format digitized doppler count on 709-magnetic tape | IBM 729 magnetic tape unit |
| | 729-format magnetic tape | IBM 729 magnetic tape unit, Milgo receiver |
| | | FLAC-format IBM 727 magnetic tape unit |
| IBM 9200 paper-tape-to-magnetic-tape converter | 729-format magnetic tape | IBM 729 magnetic tape unit |
| | | |
| | | |
| IBM 9200 paper-tape-to-magnetic-tape converter | 729-format magnetic tape | IBM 729 magnetic tape unit |
| IBM 9200 paper-tape-to-magnetic-tape converter | 729-format magnetic tape | |
| Tare II | digitized internal continuous & commutated functions on IBM-format magnetic tape | IBM 729-format tape |
| Dare | digitized cyclic functions on IBM-format magnetic tape | IBM 729 magnetic tape unit |
| | 729-format magnetic tape | IBM 714 card reader |

## PACIFIC MISSILE RANGE

PMR EXTENDS from Point Mugu and Point Arguello on the coast of California across the Pacific Ocean to Australia and Singapore. Its greatest problem is real-time data, already required for some spacecraft shots and soon to be required for manned spacecraft.

The need for translating devices on data equipment, the incompatibility of radar systems, and different data-gathering standards at various bases make up the real-time problem. The last difficulty is being tackled by IRIG (*I*nter-*r*ange *I*nstrumentation *G*roup), which is setting up mutually agreed standards to become the rules of data reduction at all missile bases. To overcome the problem of incompatible radars, PMR has standardized on FPS-16s (which feed their data to an IBM 7090 digital computer). Not all the FPS-16s are the same models, however, and some therefore require translator devices. Steps are being taken to eliminate this mismatch and provide identical interfaces in future installations.

The FPS-16s furnish three basic types of information:

- polar-coordinate date in digital form from code wheels on the antenna and the range unit, which are recorded on magnetic tape at the site and/or transmitted via data link or telephone for recording or display at a remote location.
- cartesian-coordinate data in analog form from the sine-cosine potentiometers on the antenna, and range data from the linear-range potentiometer, which are converted to digital form at the PMR radars and transmitted to automatic vectoring computers and plotting boards in the operational control centers at Point Mugu, Point Arguello, and San Nicholas Island (which select the radar that is to supply the data).
- angular data by direct mechanical pickoff from the radar synchro motors that are used in positioning other radars and optical units for simultaneous tracking.

Range support of a test vehicle involves real-time data from any combination of six radars and/or Cotars. This information, which may originate at Point Mugu, Point Arguello, or San Nicholas, can be fed simultaneously into the Arguello and Point Mugu 7090 computers via a Collins microwave data transmission system. It is sampled sequentially, bypasses the normal tape input process, and enters the computer in real time. The reduced data can be converted to analog form for visual plotting-board display, or recorded on digital tape. Simultaneously with the serial sampling of the

radar data, a magnetic tape record is made for post-flight analysis.

Wherever computers are used, troubles arise because of the differences in format between machines from different manufacturers as well as between different models from the same company. In addition, new input and output interfaces must be designed when the test conditions are changed. PMR's data-processing specialists handle these problems by designing the translating device needed in each case.

### Plea for small, modular computers

Many range-data-processing engineers believe that they would have less trouble if fewer business-type computers were used. Most of them would like to work with modular, small-scale computers (e.g. Autonetics Recomp III, CDC's 160, Packard-Bell's PB250), so that any change in interface could be handled by substituting a shelf-stocked module.

The problem of transferring acquisition data between remote tracking radars to insure reliable global tracking of spacecraft will be something new for PMR. Right now, PMR instrumentation engineers told SPACE/AERONAUTICS. ballistic-missile flight data can be predicted with sufficient accuracy for reliable acquisition data transfer. However, when you have to track a vehicle whose engines keep burning for a long period or can turn on again for further maneuvering after an initial ballistic period, the problems become much tougher.

The present state of the art generally falls well short of trajectory predictions of sufficient accuracy, not to mention the difficult task of transferring a greatly increased amount of data. Real-time computers that operate at extremely high speeds, are highly accurate, and have nanosecond access time appear to be the only answer.

### Bringing radar trackers up to speed

Tied to the problem of acquisition data transfer is that of bringing the next radar tracking system in a global chain up to the tracking speed. In long-range tracking, the radar beam is extremely narrow and its servo mass is proportionately large. Without pre-acceleration in the proper direction and at the proper rate, it

**Table II: Optical Instrumentation and Data Processing Equipment at AMR**

| Instrumentation | Form of Raw Data | Type of Data | Data Processing Reading Equipment | Output of Reading Equipment* |
|---|---|---|---|---|
| Ballistic cameras (8) | precision-glass photographic plate | light flash images from flares recorded against background of reference stars | Gaertner precision comparator | relative X-Y coordinates of plate fiducials, orientation stars & missile points recorded by hand or dictaphone & later punched into paper tape or cards |
| | | | Wild stereocomparator, Mann comparator | punched paper tape |
| Theodolites (6) | 35-mm double-frame motion-picture-type film | photographs recording azimuth & elevation angles of camera & image of the missile with respect to film frame reference point | Telecomputing theodolite film reader | digitized azimuth & elevation angles & X-Y coordinates of missile image position with respect to film frame reference point on punched paper tape |
| Fixed cameras (9) | 140-mm (5.481-in.) ribbon-frame film | missile image & pitch, yaw & roll with respect to film frame reference marks & target board images for camera orientation | Gaertner microscope | digitized X-Y measurements of target boards with respect to film fiducials &/or missile image on punched paper tape |
| | | | Coleman power comparator | digitized X-Y measurements of missile image position with respect to film fiducials on punched paper tape |
| Igor-Roti (6) | 70-mm film | pitch, yaw & roll | Richardson attitude reader | digitized attitude measurements on punched paper tape |
| | | | improved attitude reader | |
| Mitchell tracking cameras | 35-mm film | pitch, yaw & roll | Richardson attitude reader | digitized attitude measurements on punched paper tape |
| | | | Gaertner microscope | |

*All readouts on punched tape go to an IBM 9200 paper-to-magnetic-tape converter. The 729-format tape is fed into an IBM 729 magnetic tape unit and then into an IBM DR 7090 computer.

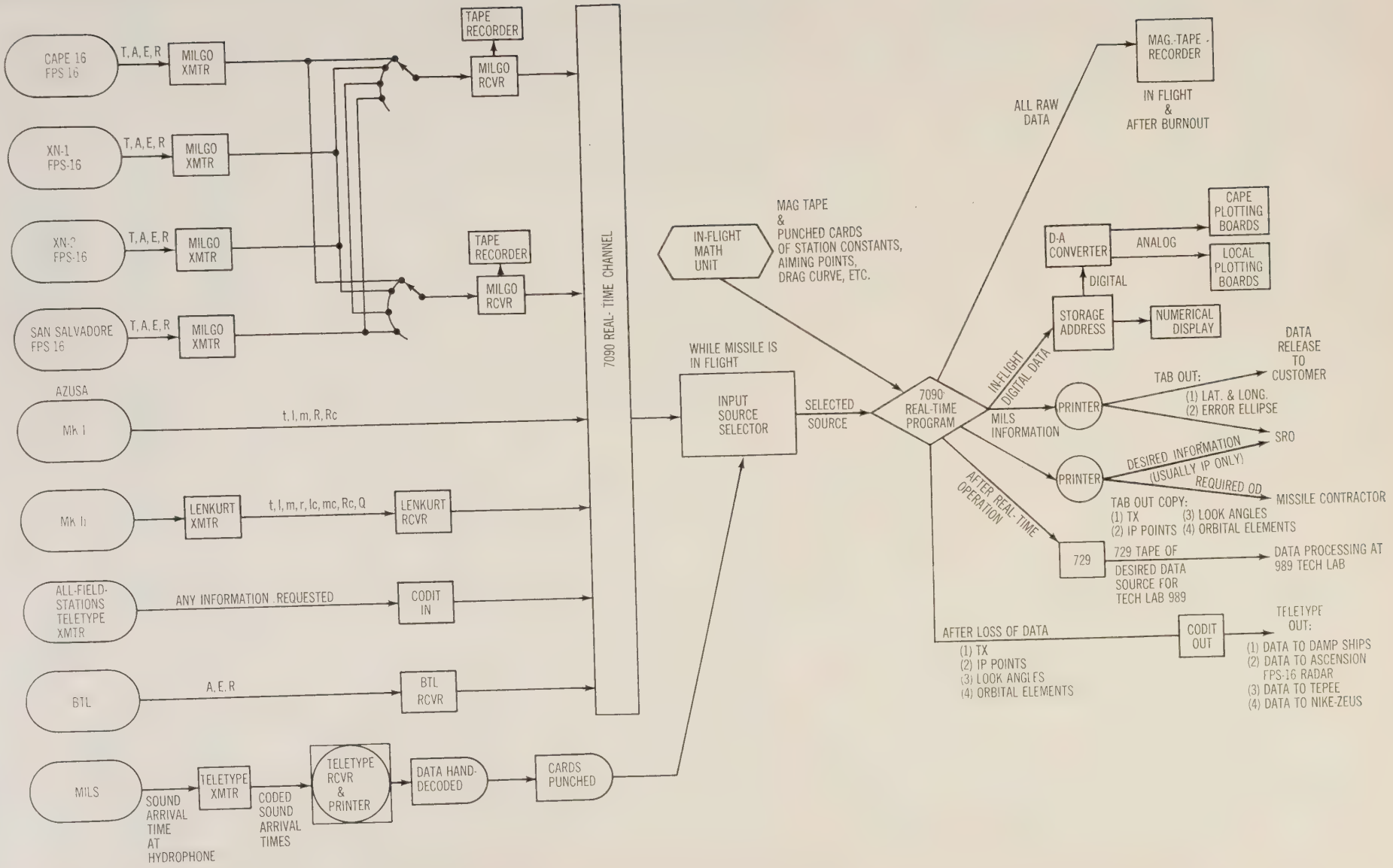



**FIGURE 1: Flow of real-time and recovery data at AMR.**

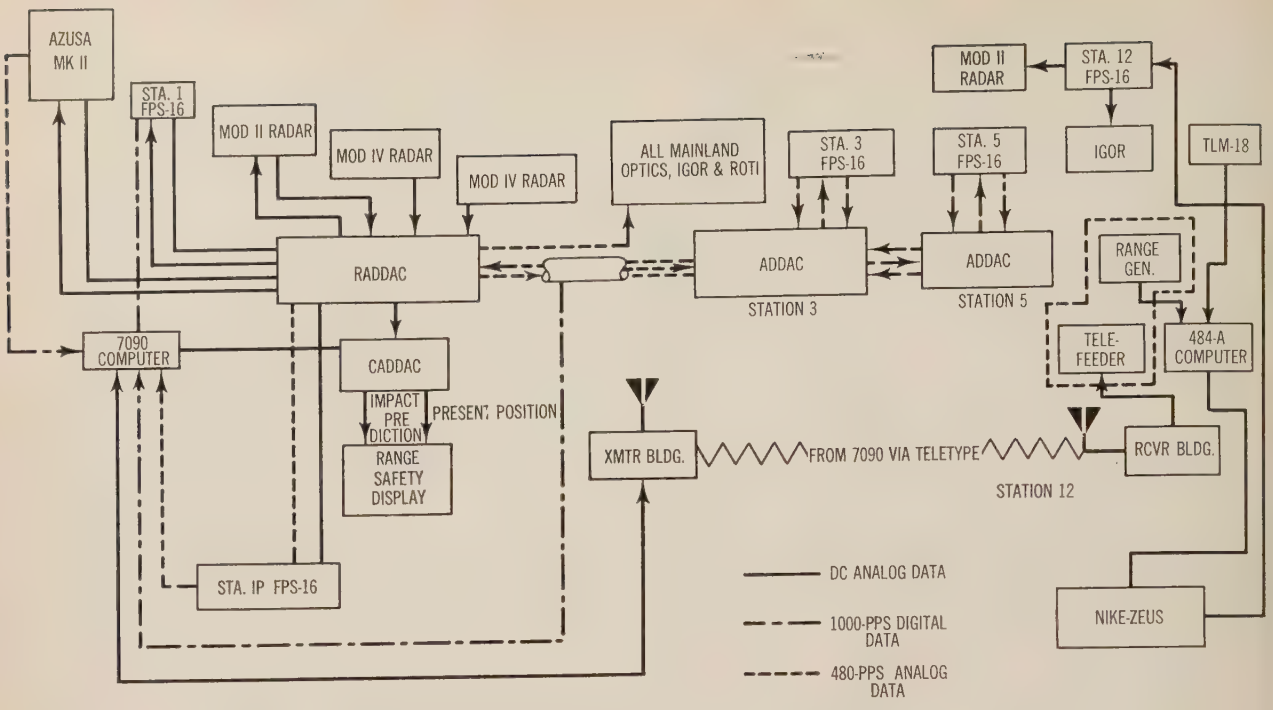



**FIGURE 2: Real-time data link designed by Lenkurt for Nike-Zeus firings.**

could not lock on. PMR handles this problem by providing the "next" tracking station with sufficient information so that the FPS-16 can be up to speed when the vehicle comes into range.

### Data sequence must be predictable

Data from any given flight are received from many sources simultaneously. To process the data through computers, they must be arranged in some predictable sequence. The present practice at PMR is to synchronize the inputs so that each uses some portion of a second.* During each such portion, the computer accepts data from one source while rejecting them from all others. The drawback of this system is that if one data source gets out of synch with the timing signal, it causes the computer to "lock out." If several signals vary in their timing, the entire computer can be locked out, and all the data are lost.

* The PMR range timing signal is a 1000-cps AM carrier containing a binary time code. The code changes every two seconds, at which time a two-second reference marker is provided, with the time signal as a reset signal.

The trend of planning at PMR points to non-synchronous operation. With this technique, a data input that varies from its time sequence merely fails to register in the computer, while another cycle continues. If the time loss is temporary, the data input registers in subsequent cycles and is useful to the extent of the average number of times it was in synchronism. In any case, the computer does not lock out and destroy all data. In the immediate future, PMR probably will use hybrid systems, with some data taken synchronously and others non-synchronously.

The question of centralized data processing at the home base vs decentralized processing, involving computers at collection sites, has not yet been resolved finally by PMR. Many range data specialists believe that small, general-purpose computers at local sites offer a practical solution to problems of processing overloads. Data processing stations located throughout the Pacific and fed by peripheral systems aboard ships or on island that is now taking shape appears to promise the best results for spacecraft operations and for shots that can tolerate delays in data transmission.

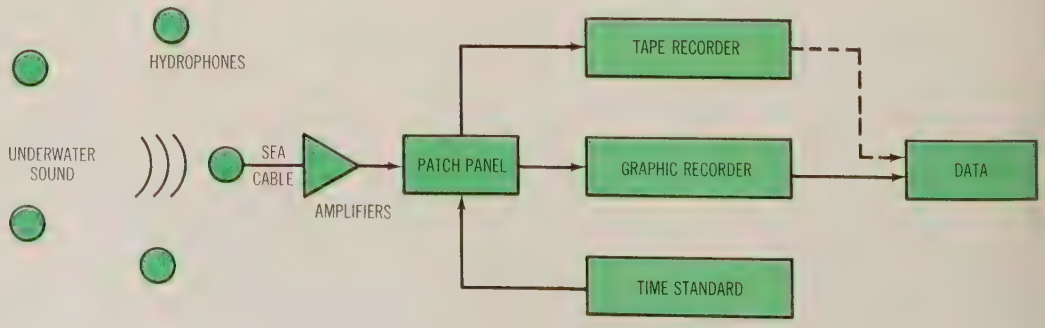



**FIGURE 3: Data flow in the missile impact location system (Mils) at AMR.**

# Selected Support Bibliography


*R. J. Eden, G. P. Hall, J. R. Needham,* "Preliminary Design Evaluation of a Mobile Missile 'Transport-Erect-Launch' Vehicle"; USAF-Aerospace Ball. Miss. & Aerospace Technology Conf., Los Angeles, Aug. '61 (class.).

*J. M. Chester, J. F. La Morte,* "Vertical Assembly, Checkout and Transfer of Large Boosters at the Launch Site"; ibid. (class.).

*J. S. Humphrey,* "Dynamic Collapse of a Rigid-Plastic Ring under a Distributed Impulsive Load"; Avco R&D Div.

*L. E. Gatzek,* "Corrosion Problems Encountered in Silo Storage of Missiles"; Aerospace, '61.

*D. L. Hall, A. J. Smith,* "Inherent Advantages of a Direct Digital Weighing System as Applied to Center of Gravity and Fuel Flow Problems"; 20th Ann. Conf., Soc. Aero. Weight Engrs., May '61.

*R. C. Truax, J. D. Ryan,* "Sea Launch of Rocket Vehicles"; SAE Natl. Aero. & Space Engrg. & Mfg. Meeting, Oct. '61.

*H. L. Lambert,* "Transportation and Ground Support Equipment for the Saturn S-IV Stage"; ibid.

*H. K. Hanchett,* "An Operational Analysis Approach To Establish Ground Support Requirements"; ibid.

*K. G. Powers,* "Mobilizing Ground Support Equipment"; ibid.

*J. G. Gaume,* "Life Support Systems for the Lunar Base"; ibid.

*N. A. Bond, Jr.,* "Maintaining Space Vehicles"; ARS Meeting, Los Angeles, May '60.

*A. B. Hazard,* "An Integrated Moonmobile-Space Suit Concept"; ibid.

*J. T. Celentano, H. S. Alexander,* "The Use of Tools in Space—An Empirical Approach"; Natl. IAS-ARS Joint Meeting, Los Angeles, June '61.

*L. D. Pigg,* "Human Engineering Principles of Design for In-Space Maintenance"; ibid.

*R. G. Demaree,* "Design Alternatives for In-Flight Maintenance"; ibid.

*S. U. Miller, N. S. Namerov, P. G. Strauss,* "A Pragmatic Approach to Bio-Instrumentation"; SAE-AFOSR Astronautic Symp., Los Angeles, Oct. '60.

*E. W. Still,* "High Altitude Chambers and Pressure Suits and Their Part in Manned Flight to the Moon"; Brit. Interpl. Soc., Apr. '60.

*J. W. Clark,* "Maintenance, Repair and Assembly in Space by Remote Means"; Hughes, Fullerton, Calif.

*S. B. Kramer, R. A. Byers,* "A Modular Concept for a Multi-Manned Space Station"; Lockheed, Sunnyvale, Calif.

*P. Moore,* "The Lunar Objective"; Symp. Expl. of Moon, Brit. Interpl. Soc., Mar. '60.

*K. W. Gatland,* "The Robot Explorers"; ibid.

*W. N. Neat,* "Man on the Moon"; ibid.

*J. R. Olivier, W. E. Dempster,* "Orbital Storage of Liquid Hydrogen"; NASA TN D-559, '61.

*L. J. Kamm,* "SATRAC: Satellite Automatic Terminal Rendezvous and Coupling"; ARS Meeting, Washington, D. C., Dec. '60.

*E. A. Smith, R. W. Connor,* "Survival Considerations for Interplanetary Missions"; SAE Aero. Meeting, Oct. '60.

*R. O. Lowrey, J. T. Ray,* "Human Factors of the Lunar Logistics Mission"; SAE Intl. Cong., Jan. '61.

*P. A. Stewart,* "Surface Exploration of the Moon"; Brit. Interpl. Soc., Sep. '60.

*S. I. Firstman, M. Kamins, B. J. Voosen,* "Automatic Checkout Equipment: Employment and Design Considerations"; Rand Rep. R-358, '60.

*A. A. Barbour,* "Cost Implications of Automating Air Force Test Equipment: A Suggested Procedural Approach"; Rand Res. Memo. RM-2229, '58 (conf.).

*Firstman, Voosen,* "Missile Prelaunch Confidence Checkout: Content and Equipment Design Criteria"; Rand Res. Memo. RM-2485, '60.

*Firstman, B. Gluss,* "Search Rules for Automatic Fault Location"; Rand Res. Memo. RM-2514, '60.

*Kamins,* "Determining Checkout Intervals for Systems Subject to Random Failures"; Rand Res. Memo. RM-2578, '60.

*Barbour, Firstman, Kamins,* "Standardization of Automatic Test Equipment: A Preliminary Discussion"; Rand Res. Memo. RM-2685, '60.

*Voosen,* "Manpower Implications of Test Automation"; Rand Res. Memo. RM-2719, '61.

*J. R. Brom, Firstman,* "Operational Criteria for the Design of Missile Readiness Testing Programs and Equipment"; Rand Res. Memo. RM-2735, '61.

*K. H. Meyer,* "The Role of Automatic Checkout Equipment in Air Force Data Systems"; Rand Res. Memo. RM-2741, to be publ.

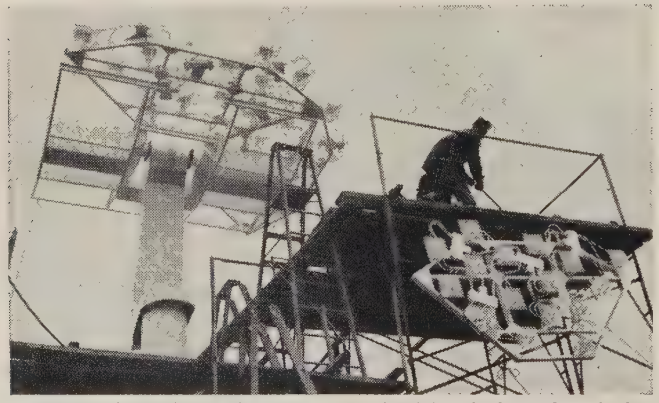
*Firstman et al.,* "An Omnibus of Briefing Papers on Analysis of Automatic Checkout Equipment and Aids to Its Design"; Rand Res. Memo. RM-2750, '61.

*N. Bond, A. Swain,* "Human Factors in Checkout Equipment: An Annotated Bibliography"; Rand Res. Memo. RM-2756, to be publ.

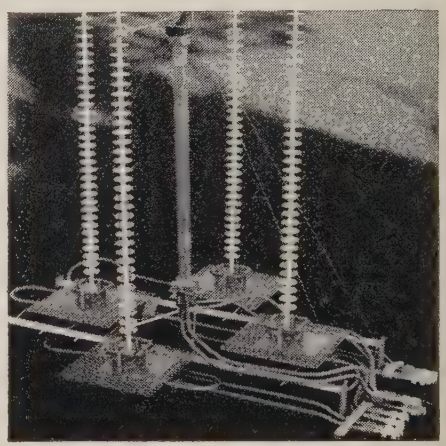
*T. O. Wright,* "A Different Approach to Ground Equipment Development"; AFSC BSD.

Individual unit assembly is first step in construction of antenna. Here four dipole antennas mounted on ground screen are being connected to one end of Foamflex feed lines. Special Phelps Dodge connectors are used to link the lines to the dipoles and four-way power dividers.

Completed quadrant elements, ready for placement on pedestal mount. Each quadrant is pre-assembled in exactly the same manner.



Completed quadrant elements are raised to platform for placing into position on pedestal mount.



An example of a center element unit that can be inserted into the Avien-Bogner array. This element forms a separate unit that can also be used as a portable ultra high frequency antenna.

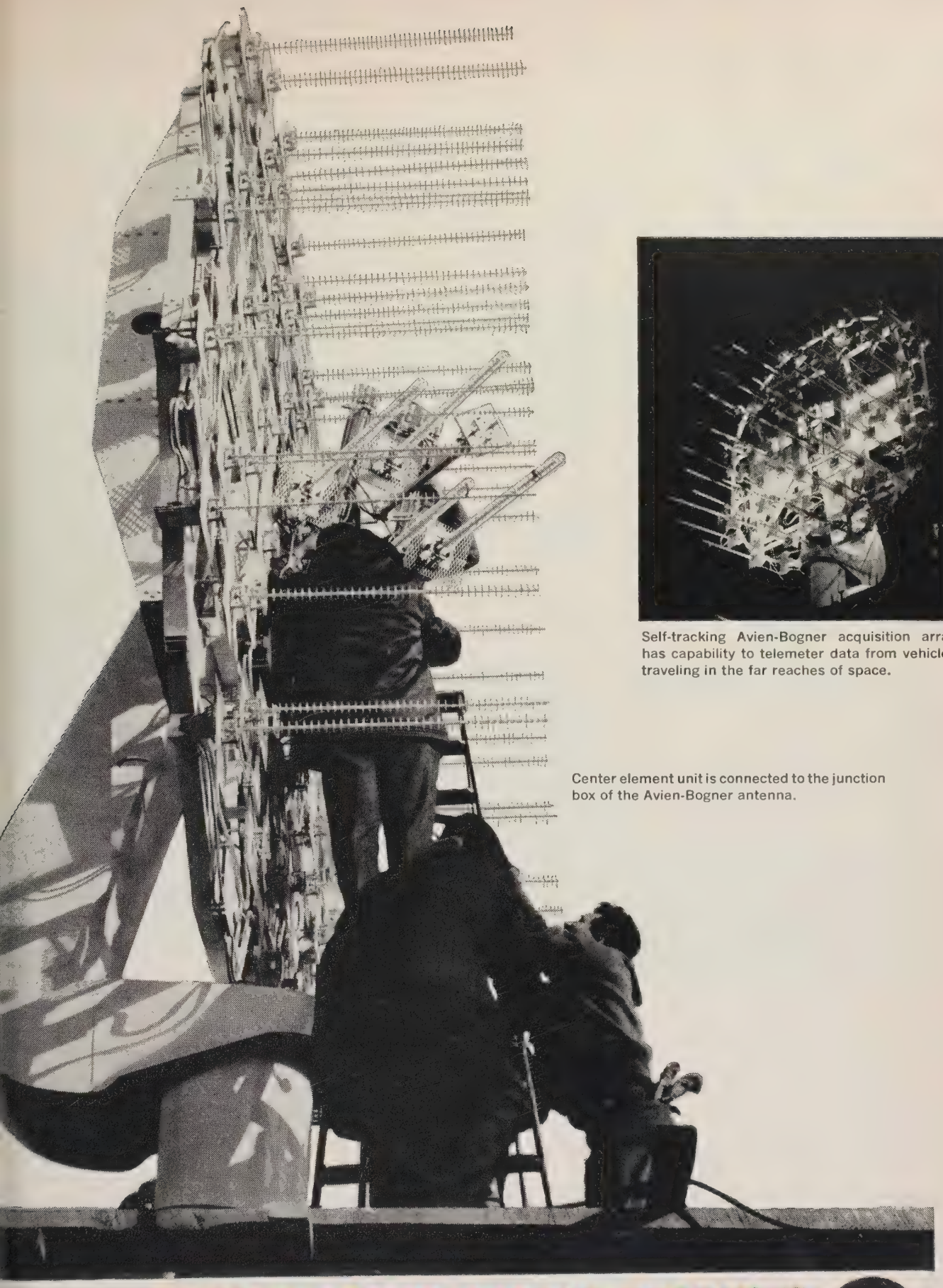
# *Foamflex® Coaxial Cable helps put and keep this advanced antenna system on the track!*

A feed network of 3/8", 50 ohm Foamflex coaxial cable is a critical part of the fully automatic Avien-Bogner acquisition and tracking antenna that represents an advance in the state of the antenna art. The efficient operation of this sensitive antenna is greatly increased by the low loss, high phase stability and electrical uniformity of its weatherproof Foamflex feed line assemblies. Special connectors, designed and fabricated by Phelps Dodge, link the Foamflex lines to double-tuned, strip-line, four-way power dividers in each quadrant element of the antenna.

Designed for Edwards Air Force Base, this modular array is assembled from identical quadrants, each equipped with power dividers, dipole antennas and cigar elements. In contrast to the heavier, fixed-type paraboloids, the lighter, smaller Avien-Bogner model costs less, yet has high acquisition capability for telemetry information through the use of three automatic tracking modes. Quadrant elements may easily be replaced when changes are desired in frequency bands, due to the simple design and construction of this antenna.

The feed system was planned, fabricated, calibrated and installed by A-T Electronics, New Haven, Conn. Accurate uniformity of electrical length for each cable was maintained from cable to cable within one degree at 2200 megacycles after bending.

The outstanding qualities of semi-flexible, aluminum-sheathed Foamflex have been proved in a number of applications where low loss, long operating life and a low noise to high signal level ratio are essential. If your specifications call for a coaxial cable of the highest efficiency, we recommend you investigate the capabilities of Foamflex.





Self-tracking Avien-Bogner acquisition array has capability to telemeter data from vehicles traveling in the far reaches of space.

Center element unit is connected to the junction box of the Avien-Bogner antenna.

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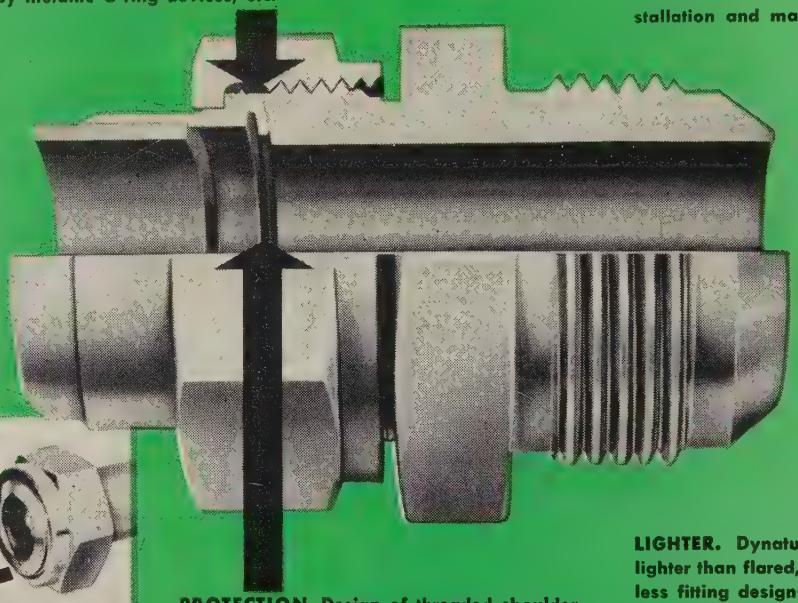
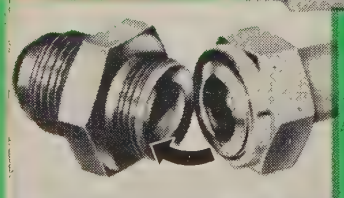
**DYNAMIC SEALING.** Dynatube design incorporates a dynamic seal whose efficiency increases with elevated pressures—without need for extreme machine finish such as that required by metallic O-ring devices, etc.

**SPACE SAVER.** Smaller envelope of Dynatube means easier wrench access, less distance across hex corners, less protrusion of total connection and less clearance needed for installation and maintenance in critical uses.





**METAL-TO-METAL** contact forms full seal at torque range between 26 foot-pounds and 200 foot-pounds, compared with 7 foot-pound range (110 to 117 fp) for flared fittings in the —16 size.

**PROTECTION.** Design of threaded shoulder permits the nut to act as a protective cover for the tube end, minimizing possibility of damage to seal. Dynatube is considerably stronger than standard AN or MS fittings.

**LIGHTER.** Dynatube fittings are markedly lighter than flared, modified flared and flareless fitting designs . . . offering up to 74% weight savings over flared fittings, combined with zero leakage because of pre-determined stress level at seal.

*Dynatube is a Resistoflex trademark. U.S. and Foreign patents applied for.

Dynatube, another *first* by Resistoflex, is an all-new concept in metal rigid tube connections . . . providing a superior seal for high performance hydraulic, pneumatic, fuel and oxidizer systems.

Dynatube provides maximum performance because

- The seal is controlled by precision dimensions built into the fitting
- The fitting design is based on pre-determined stress level at the sealing point
- Torque range is extremely wide

Dependence on surface finishes of sealing seats, concentricity of AN and MS screw machine parts and torque applicatio completely eliminated with Dynatube.

Severe temperature cycling does not affect the Dynat seal, which maintains its reliability up to 700° F. and hig depending on application. Not sensitive to torque degradat Dynatube has a smaller envelope and is lighter and stro than corresponding AN or MS fittings. Meets or exceed performance requirements of proposed MIL-F-18280B.

Here is the answer to your tube sealing problems. your Resistoflex field engineer about Dynatube, or writ Resistoflex, Roseland, N. J. for Bulletin DY-1.

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# Support Capabilities at a Glance

*In the following pages, we present the first large-scale, quick-reference index to the aerospace industry's capabilities in ground support. Nearly 400 companies are referenced according to 15 basic support areas in which they offer their products and/or services.*

*This index is backed up by brief descriptions covering the support specialties, contract experience, and literature of each company. Also given are specific contacts at each company.*

*To set up our index, we got in touch with over 2200 companies by mail, telephone, or in person. The companies that qualified for the index were then asked to indicate the categories under which they wanted to be listed, and these requests were checked against the supporting data that we also requested.*

*We believe that this is the most nearly comprehensive genuine capabilities index ever published, but we also know that it is not 100 per cent comprehensive—we know we must inadvertently have missed a few companies. Please let us know of any omissions that you may notice, so that we may update our index for future editions.*

*There are some companies in the index for which no specific capabilities are referenced. These companies are, however, referenced to their advertisements in this section, from which further details may be taken. Because their data arrived too late, there are also some companies listed in the index for which no descriptions of support specialties and contract experience are given.*

*the Editors*

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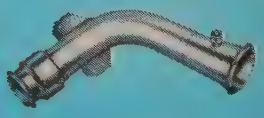

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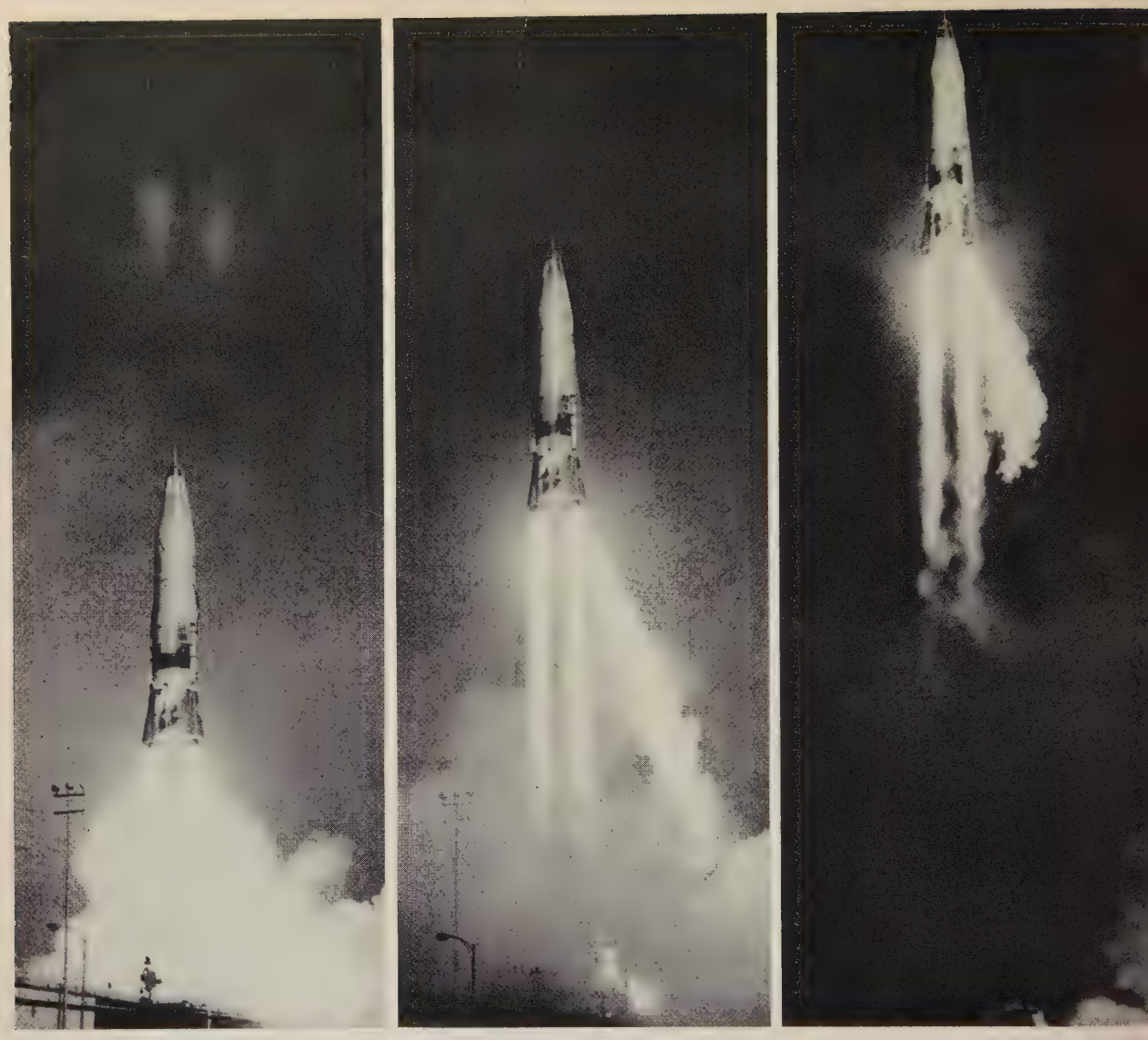

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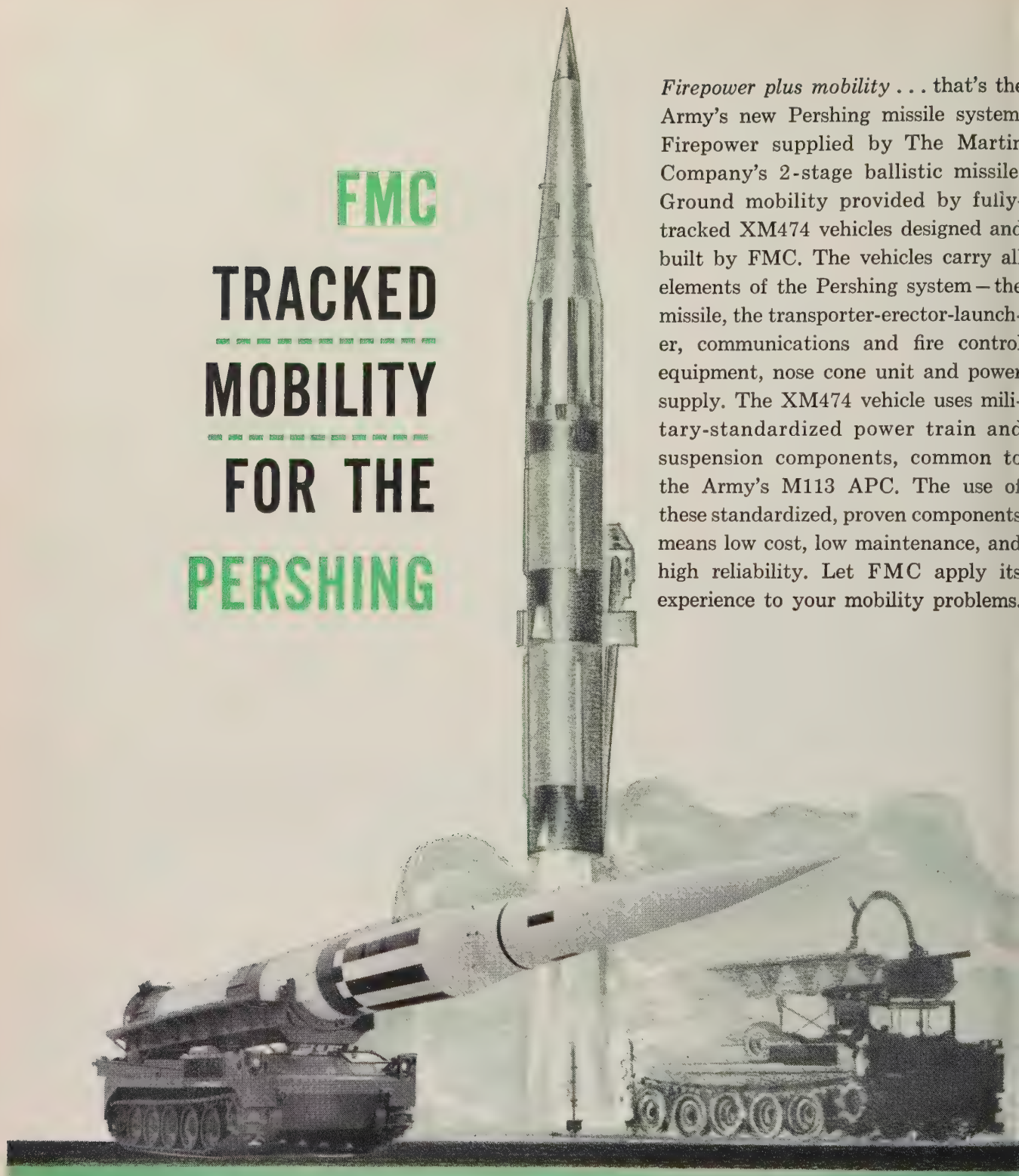

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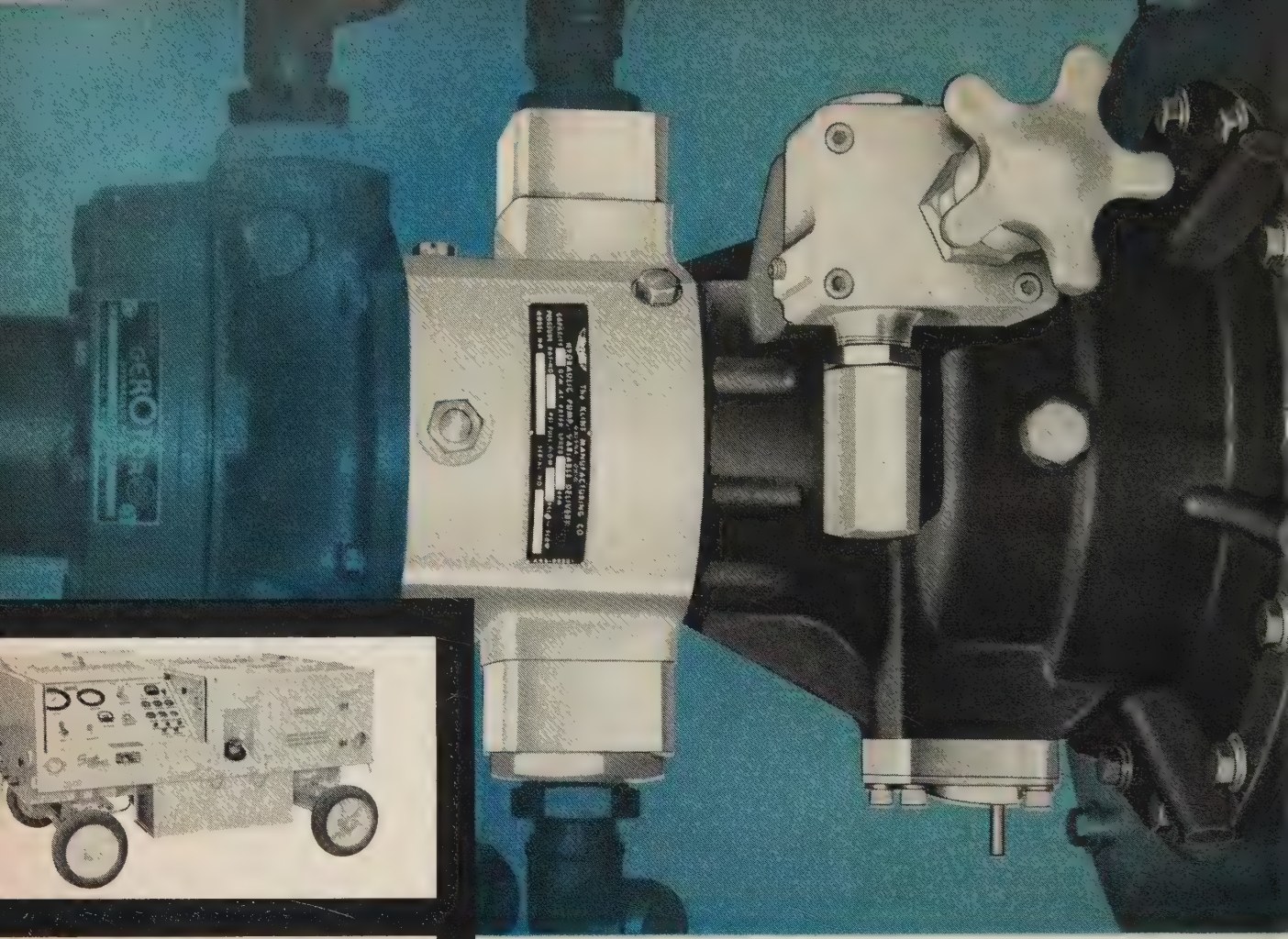



Kline THRU-TORQ Pump driving a boost pump is mounted on Model AHT-54A Sun Test Stand. Hydraulic lines have been removed for clarity.

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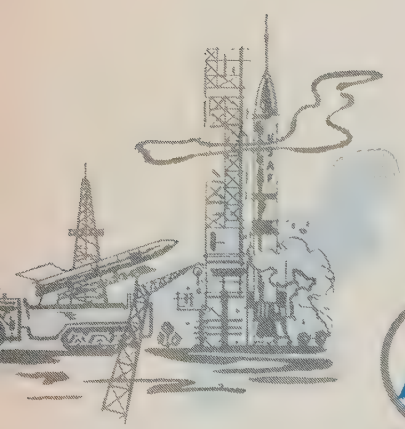

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| Turbocraft | | | • | | | | | | | | | • | | | • | |
| Uni-Flex Mfg. & Engrg. | | | • | | | | | | | | | • | | | • | |
| Unit Crane & Shovel | | | | • | | | | | | | | | | | • | 5 |
| United Control | | | | | | | • | • | | | | • | | | • | |
| United Mfg. (Cleveland, Ohio) | | | | • | | • | | | | | | | | | • | |
| United Mfg. (Hamden, Conn.) | | | | | | | • | • | | | | | | | • | |
| United Nuclear | | | | • | | | | | | | | | • | | • | |
| Vacco Valve | | | • | | | | | | | | | • | • | | • | |
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| Vinson Mfg. | | | | • | • | | | • | | | | | | | • | |
| Wang Labs. | | | | | | | | • | | | • | | | | • | |
| Washington Technological Associates | | | | • | | • | | • | • | • | • | | | • | • | |
| Watertown Div., New York Air Brake | | | | • | • | | | | | | | | | | • | |
| Waugh Engrg. Div., Foxboro | | | • | • | | | | | | | | | | | • | |
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| Westinghouse Electric | | | | • | | | • | • | • | • | • | | • | • | • | |
| Westinghouse Electric Aerospace Electrical Dept. | | | | | | | • | • | | | | | | | • | |
| Whittaker Controls Div., Telecomputing | | | • | • | | | | | | | | • | | | • | |
| Whittaker Gyro Div., Telecomputing | | | | | | | | • | | | | | | | • | |
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| Yardney Electric | | | | | | | • | | | | | | | | • | |
| Zippertubing | | | | • | • | | • | | • | • | | • | | | • | |

# Company Specialties and Contract Experience

**ACCESSORY PRODUCTS CO.,** 616 W. Whittier Blvd., Whittier, Calif.

• SPECIALTIES—Design, development, and manufacture of pressure control systems for pneumatics and hydraulics.

• CONTRACTS—Transport pressure control unit, nitrogen pressure control units, and test pressure control unit for Atlas.

• LITERATURE—Ground Support Equipment (No. **1000** on Card); Servo Dome Pressure Regulators (No. **1111** on Card); APCO Hand Valves (No. **1112** on Card).

• CONTACT—O. A. Cordes, Sales V-P, OX 3-3747.

**ACCUTEST EQUIPMENT DIV., REF DYNAMICS CORP.,** 393 Jericho Turnpike, Mineola, N.Y.

• SPECIALTIES—portable and fixed checkout equipment for hydraulic, pneumatic; fuels system test.

• CONTRACTS—HCT-40 hydraulic components test stand for Titan launcher, FMT-1, fuel manifold pressure test stand for J-57, J-75 and J-52 engines, hydraulic filtering cart HFC-1 for Pershing.

• LITERATURE—Fuel Manifold Pressure Test Stand (No. **1113** on Card); Hydraulic Components Test Stand (No. **1114** on Card); Hydraulic Filtering Cart (No. **1001** on Card).

• CONTACT—Jack Simon, Applications Engineer, PI 2-8400.

**ACME PRECISION PRODUCTS, INC.,** 215 Findlay St., Dayton 3, Ohio.

• SPECIALTIES—Design and production of hydraulic test stands, fuel conditioners, special air conditioners, liquid oxygen-nitrogen generatng equipment, runway overrun barriers.

• CONTRACTS—NR-5 portable air conditioner, one-ton capacity skin mounted LOX generators, and ejector bomb rack for Navy.

• LITERATURE—Type NR-5 Air Conditioner (No. **1115** on Card); Portable Hydraulic Test Stand (No. **1116** on Card); Lox Equipment (No. **1002** on Card).

• CONTACT—D. M. Odom, Chief Engineer, 253-5121.

**ACOUSTICA ASSOCIATES, INC.,** 10400 Aviation Blvd., Los Angeles 45, Calif.

• SPECIALTIES—Automatic checkout of propellant systems for blockhouses and mobile trailers; trainers to simulate propellant loading countdown; systems design and production of propellant loading and engine sequence cut-off initiating systems; propellant control devices based on ultrasonic techniques.

• CONTRACTS—Atlas portable field checkout equipment, conventional GSE for use with propellant utilization systems, and depot maintenance computer analyzer for Atlas.

• CONTACT—Charles W. Thomas, Marketing Mgr., Adv. Systems Div., ORchard 0-4803, Ext. 111, 112.

**ADLER ELECTRONICS INC.,** 1 Le Fevre Lane, New Rochelle, N. Y.

• SPECIALTIES — Communications systems, automatic checkout, control and trajectory systems.

• CONTRACTS—Sub contract on ground tracking and communications to and from satellite for Courier satellite, air traffic control maintenance and test equipment for BuShips.

• LITERATURE—Production line to Pre-Flight Checkout (No. **1003** on Card).

• CONTACT—C. P Johnson, Director of Military Products, NE 6-1620.

**ADMIRAL CORP.,** 3800 Cortland St., Chicago 47, Ill.

• SPECIALTIES—Electro optical missile tracking techniques especially during launch and terminal phases, IFF equipment checkout systems, and very low noise motor-generator sets for supplying primary power to GSE.

• CONTRACTS—Radar test set for general aircraft use, Navy, AF, Army and NATO, IFF checkout, TV tracking of guided missiles.

• LITERATURE—Transistorized image Orthicon Camera (No. **1117** on Card); Beacon Test Set, Video Test Generator (No. **1004** on Card).

• CONTACT—J. Yashon, Mgr., Market Development, SP 2-0100.

**ADVANCED STRUCTURES DIV., TELECOMPUTING CORP.,** 801 Royal Oaks Dr., Monrovia, Calif.

• SPECIALTIES—Mobile heaters and air conditioners, portable cooling units using distilled water and FC-75 as the heat transfer media, electronic console air conditioners, air and nitrogen missile conditioning systems, and liquid propellant conditioning systems, honeycomb sandwich.

• CONTRACTS—Saturn 250-ton refrigeration and 600-kw heat modular air and nitrogen conditioning unit. Advent 2-ton air conditioning unit. Discoverer, Samos, and Midas mobile unit with 16-ton refrigeration and 100,000-btu/hr heating modules.

• LITERATURE—Portable Liquid Cooling Unit (No. **1806** on Card); Electronic Console Air Conditioner (No. **1118** on Card); Modular Air Conditioner (No. **1005** on Card).

• CONTACT—R. A. Andersen, Manager-Sales, EL 8-3211 Ext. 214.

**ADVANCED TECHNOLOGY LABORATORIES DIV. OF AMERICAN-STANDARD,** 369 Whisman Rd., Mountain View, Calif.

• SPECIALTIES—Design and development of electro-mechanical and electro optical simulation, test and checkout equipment.

• CONTRACTS — Horizon scanner checkout equipment for Discoverer, secondary junction checkout console for simulating satellite injects and sequential

checking outjets.

• LITERATURE—Facilities and Capabilities Brochure (No. **1006** on Card).

• CONTACT—F. E. Lusch, Senior Engineer. YO 8-4461.

**AEROQUIP CORP., AIRCRAFT DIV.,** 300 Southeast Ave., Jackson, Mich.

• SPECIALTY—Medium and high pressure Teflon hose (to 24,000 psi burst) for hydraulic, fuel, pneumatic, nitric acid, and similar compound transfer; self sealing couplings for ground hydraulic, pneumatic, and fuel systems.

• LITERATURE—Products Catalog (No. **1007** on Card).

• CONTACT—Fred Schwier, General Sales Mgr., ST 3-2585.

**AEROSPACE DIV., AERONCA MANUFACTURING CORP.,** Box 536, Baltimore 3, Md.

• SPECIALTIES—Automatic checkout and fluid handling equipment housed in lightweight shelters on mobile vans.

• CONTRACTS—General purpose telemetry ground station for surface vehicles, automatic checkout equipment for Talos, flashing light system calibration and checkout equipment for Atlas.

• LITERATURE—Constant Altitude Plan Position Indicator (No. **1119** on Card); Mobile General Purpose Telemetry Ground Station (No. **1008** on Card).

• CONTACT—C. W. Harvey, Mgr., Technical Services, SO 6-5000 Ext. 5.

**AERO-TEST EQUIPMENT CO., INC.,** 8401 Chancellor Row, Dallas 7, Texas

• SPECIALTIES—Design, manufacture and installation of test and simulation facilities, hydraulic, pneumatic, electrical and electronic test stands for post-overhaul testing, aircraft and missile components and systems; portable electrical, pneumatic and hydraulic checkout equipment; altitude simulation facilities for altitude, environmental and rapid decompression testing; graphic and conventional instrumentation control panels and consoles.

• CONTRACTS—Family of research altitude chambers for the Aerospace Medical Center at Brooks AFB, hydraulic test stand and auxiliary electronic console for component testing B-58 armament system; low pressure facility for aircraft escape capsule trainee.

• LITERATURE—Systems Instrumentation (No. **1120** on Card); Research Altitude Chambers, (No. **1121** on Card); Turbo Compressor Test Facility (No. **1009** on Card).

• CONTACT—K. Bishop, Sales Mgr., ME 1-5310.

**AEROTEST LABORATORIES, INC.,** Comac Rd., Deer Park, N. Y.

• SPECIALTIES—Fuel pump and valve test stands.

• CONTACT—L. D. Brown, Chief Engr.

**AETRON, DIV. AEROJET-GENERAL CORP.,** 410 N. Citrust Ave., Covina, Calif.

• SPECIALTIES—A&E design of multi-million pound thrust test stands, launching towers and pads, mechanized propellant process plants, chemical and physical laboratories; propellant handling and transfer of liquid oxygen, liquid nitrogen, liquid hydrogen red fuming nitric acid, nitrogen tetroxide, unsymetrical dimethyl hydrazine, and nitrogen and helium propellant pressurization systems; ground power and cooling, e.g. high altitude test chambers, low temperature conditioning for test stands, DC power supplies; launch monitoring and control, e.g., instrumentation and range safety systems mobil telemetry checkout stations; launch and trajectory data.

• CONTRACTS—Test stand, block house, propellant storage and transfer systems, instrumentation and control including A to D data handling system for saturn static testing data accumulation of missile performance; telemetry vans, checkout equipment for missile command destruct system and O and C consoles in support of Atlas.

• LITERATURE—Missile Checkout Equipment (No. **1122** on Card); Rocket Engine Test Stands (No. **1123** on Card); Instrumentation and Range Safety System at Vandenberg AFB (No. **1010** on Card).

• CONTACT—E. L. Mleczko, Mgr., Customer Relations Div.

**AINSLIE CORP.,** 531 Pond St., Braintree 85, Mass.

• SPECIALTIES—Antennas and reflectors, ground handling trailers, dollies, cradles, etc.

• CONTRACTS—For Advent and range equipment for Radiation, Inc.

• LITERATURE—General Brochure (No. **1124** on Card); Antenna and Pedestal Sheets (No. **1011** on Card).

• CONTACT—H. W. Ainslie, Jr., President, VI 8-0850.

**AIRATERRA,** 620 Paula Ave., Glendale 1, Calif.

• SPECIALTIES—Liquid propellant, couplings, valves, hardware for ammonia, helium, hydrogen, nitrogen, hydrazine, lox, fluorine; fuel transfer components for high flow and high pressure systems.

• CONTRACTS—Parts for Atlas, Titan 1, and Polaris.

• LITERATURE—Couplings (No. **1125** on Card); Nipples (No. **1126** on Card); Ground Support (No. **1012** on Card).

• CONTACT—Wm. J. Kennedy, Chief Project Manager.

**AIRBORNE ACCESSORIES CORP.** 1414 Chestnut Ave., Hillside 5, N. J.

• SPECIALTIES — Electromechanical actuators used in linear and rotary AC and DC.

• CONTRACTS—Erection system for Pershing carrier.

• LITERATURE—General catalog (No. **1013** on Card).

• CONTACT—C. Hood II, Director of Engrg., MU 8-0250.

**AIRCRAFT ARMAMENTS, INC.,** Cockeysville, Md.

• SPECIALTIES — Bomb handling devices, rocket sleds, and transport trailers; automatic checkout equipment; training and simulation systems for radar, guided and ballistic missile, ordnance and ASW training programs.

• CONTRACTS—Missile trainer for Sergeant countdown; maintenance analysis test set for Polaris fire control system.

• LITERATURE—Engineering capabilities and Experience (No. **1014** on Card).

• CONTACT—W. E. Mann, Manager, Program Development, NO 6-1400, Ext. 304.

**AIRESEARCH MANUFACTURING CO. OF ARIZONA,** 402 S. 36th St., Phoenix 34, Ariz.

• SPECIALTIES—Lightweight and compact gas turbine compressor and power package that supply electrical power for checkout, guidance and missile positioning as well as pneumatic power for air conditioning, snow and ice removal, and operation of pneumatic actuators, etc.; valves and control systems for cryogenic and non-cryogenic fluids and propellants, hydraulic missile erection systems.

• CONTRACTS — Pershing-Martin AC and DC gas turbine generator and pneumatic power (air conditioning) for Pershing, gas turbine generator sets for Sergeant; fill and drain system for Atlas.

• LITERATURE—Mobile Ground Service Units (No. **1127** on Card); Ground Support Equipment for Missile Weapons (No. **1015** on Card).

• CONTACT—W. D. Aistrop, Engineering Supervisor, BR 5-6311.

**AIRESEARCH MANUFACTURING CO. OF LOS ANGELES,** 9851 Sepulveda Blvd., Los Angeles 45, Calif.

• SPECIALTIES—Vapor cycle and air cycle; electronics cooling advanced concepts in ground power particularly in high frequency as well as conventional 400 cycle and 28 volt DC.

• CONTRACTS—Ground air conditioning for Sergeant, electronics cooling for Hawk, ground air conditioning for Pershing.

• LITERATURE—Ground Support Environmental Equipment (No. **1128** on Card); Electronic Environmental Control System, (No. **1129** on Card); Cryogenic Systems (No. **1016** on card).

• CONTACT—P. M. Bartlett, Sales Manager, SP 6-1010.

**AIR LOGISTICS CORP.,** 3600 E. Foothill Blvd., Pasadena, Calif.

• SPECIALTIES—Ground handling equipment for missiles, missile propulsion systems, re-entry vehicles, jet engines, aircraft, special weapons and stores.

• CONTRACTS—Complete ground handling, installation and removal equipment for GAM-77 Hound Dog; Ground power unit for moving B-52 under severe weather conditions; air transportable containers for jet engines.

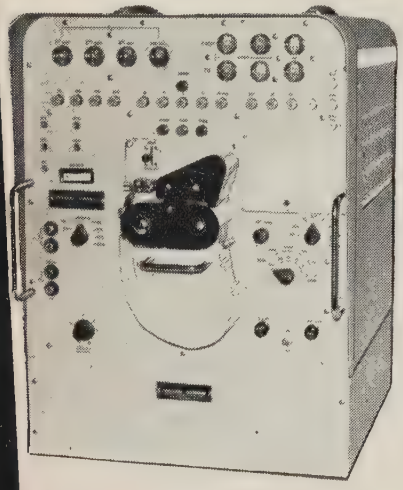
• LITERATURE—Aircraft and Missile Ground Support (No. **1130** on Card); Engineering Status Report (No. **1017** on Card).

• CONTACT—J. C. Walshe, Manager, Customer Relations & Contracts, SY 6-7191 Ext. 10.

**ALCAR INSTRUMENTS, INC.,** 411

THE Lavoie LA-303
ROBOTESTER

Criterion FOR CRITICAL CHECKOUT



Where time and reliability are critical, the Robotester sets the pace in precision electronic checkout. New levels of speed and accuracy are made possible through pre-programmed acceptance standards. High speed sampling and comparison yield split second recognition, isolation and identification of abnormal functions. Up to 100 tests per minute can be made between any two of 250 circuit points randomly selected. When out-of-tolerance value is met, operation stops, and the isolated faulty circuit is identified by digital readout.

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Write for complete technical details and applications.

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MORGANVILLE, NEW JERSEY

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Robbins Ave., Trenton, N.J.

• SPECIALTIES—Ultrasonic nondestructive testing, cleaning and degreasing systems.

• CONTRACTS—Ultrasonic degreasers for engine strainers.

• CONTACT—Dr. Hugh H. Darby, President, TU 3-2900.

**ALLIS-CHALMERS MFG. CO., DEFENSE PRODUCTS DIVISION,** Box 512, Milwaukee 1, Wis.

• SPECIALTIES — Earthmoving equipment; centrifugal pumps; fork lift trucks; engine-generator sets, transformers, substations, switchgear, voltage regulators; telemetry data processing; automatic recording and monitoring; telemetering receiving station; propellant checkout; propellant x-ray inspection.

• CONTRACTS—Diesel engine-generator sets to power Mercury tracking stations; 25-million volt betatron for nondestructive testing of Minuteman fuel and structure; electric power distribution and control equipment for Titan II.

• LITERATURE — Allis-Chalmers from A to Z (No. **1018** on Card).

• CONTACT—Ray Bell, Manager, Defense Systems Dept., SP 4-3600 Ext. 716.

**ALTO SCIENTIFIC CO., INC.,** 4083 Transport St., Palo Alto, Calif.

• SPECIALTIES—Electronic checkout consoles for telemetry systems, guidance, flight control, timing systems, computer checkout, etc, components for above systems in the nature of signal simulation equipment, UHF receivers, square wave generators, command modulator-pulsers, voltage monitors, etc.

• CONTRACTS — UHF telemetry checkout and guidance checkout for satellite system; temperature sensor for Skybold. tone generators for Centaur.

• LITERATURE—Electronic Subsystems Checkout, (No. **1131** on Card); GSE Electronic Components (No. **1019** on Card).

• CONTACT—Dr. David Cherry, General Manager, DA 1-3434.

**AMERICAN AIR FILTER CO., INC., DEFENSE PRODUCTS DIV.,** 310 3rd St., Rock Island, Ill.

• SPECIALTIES—Portable and fixed environmental systems including cooling, heating, ventilation, humidity control, CBR filtration, etc. for support of electronic checkout and monitoring systems, guidance computers and processors, aircraft and missiles, vans, trailers, etc.

• CONTRACTS—Supply heat to Atlas thrust section prior to launch, environmental control for Minuteman launch facility and control, environmental control for Atlas mobile automatic programmed checkout equipment.

• LITERATURE—Defense Products Brochure (No. **1020** on Card).

• CONTACT—D. B. Roush, Manager, Contract Administration, 788-9311 Ext. 405.

**AMERICAN BRAKE SHOE CO.,** 530 Fifth Ave., New York 36, N. Y.

• SPECIALTIES — Hydraulic test stands, strain gage pressure transducers, and electro-hydraulic servo systems and controls.

• CONTRACTS—Pumps for GAM 77; Pressure transducers for Mercury; hydraulic radar antenna drives.

• LITERATURE—R & D brochure, Ground Support Products (No. **1021** on Card).

• CONTACT — Robert Carruthers, Research Center, LA 9-3450.

**AMERICAN MACHINE & FOUNDRY CO., GREENWICH ENGINEERING DIV.,** 11 Bruce Place, Greenwich Conn.

• SPECIALTIES—Architectural design and development of shelters and foundations, closure mechanisms, shock suspension systems, blast doors, and special missile launchers; base facilities such as air conditioning, heating, ventilation deluge, and fire fighting facilities and equipment; operational support systems management; advanced concepts for launchers and erectors: such as silo-lift; programmed weapon cart, automatic loading, aiming and firing; retractable-roof sheltered launchers and mobile launcher.

• CONTRACTS—Hard base launcher system for Titan; in-silo launcher system for Atlas; technical study of the manufacturing, logistical and operations requirements of a complete ground complex for launching and recovering Dyna-Soar type orbital vehicles.

• LITERATURE—Aerospace Brochure (No. **1132** on Card); Blast Closure Valve Brochure (No. **1133** on Card); Government Products Group Brochure (No. **1022** on Card).

• CONTACT—J. N. Albaugh, Mgr., New Programs, NO 9-7400 Ext. 356.

**AMERICAN POWER JET CO.,** 705 Grand Ave., Ridgefield, N. J.

• SPECIALTIES—Ground Handling, storage and transport for missiles, propellants, space vehicles, etc.

• CONTACT—George Chernowitz, Director, WH 5-8203.

**AMERICAN ROCKET CO.,** 22634 Goddard Rd., Taylor, Mich.

• SPECIALTIES—Design of solid propellant launch and hold facilities, large solid propellant booster handling at launch site, specialized solid propellant handling and transport.

• LITERATURE—Plastic Shelters for Solid Rockets (No. **1023** on Card).

• CONTACT—James Wells, GSE Eng., LO 5-3408 (Detroit).

**AMERICAN STEEL FOUNDRIES, HAMMOND DIV.,** Hohman Ave. & Hoffman St., Hammond, Ind.

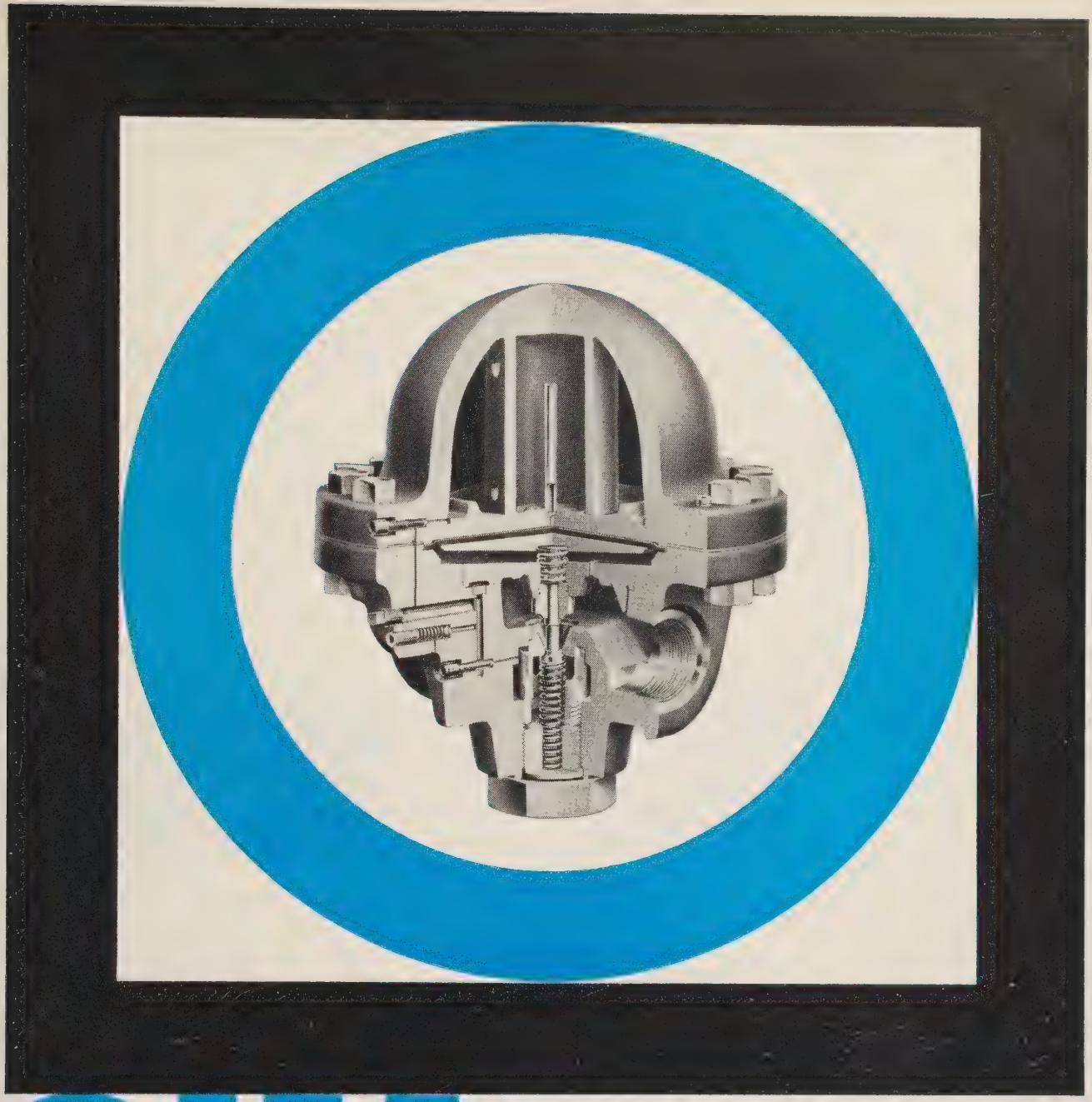
• SPECIALTIES—Development and production of hot wound steel coil for ground support applications.

• CONTRACTS—Strut suspension springs for Atlas silo installations, springs for prototype Titan II silo installations, springs for hardened cable entrances for Minuteman installations.

• LITERATURE—Hot Coiled Compression Spring Design Tables. (No. **1024** on Card).

• CONTACT—R. H. Cantwell, Mgr., WE 1-1900.

**ANACONDA METAL HOSE DIV., ANACONDA AMERICAN BRASS CO.,**



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MONSANTO FLUIDESIGN SERVICE OFFERS YOU:

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3. Time-saving facilities for testing new uses
4. More *job-proven* functional fluids than any other manufacturer in the world
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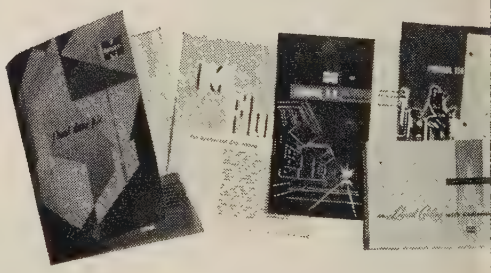

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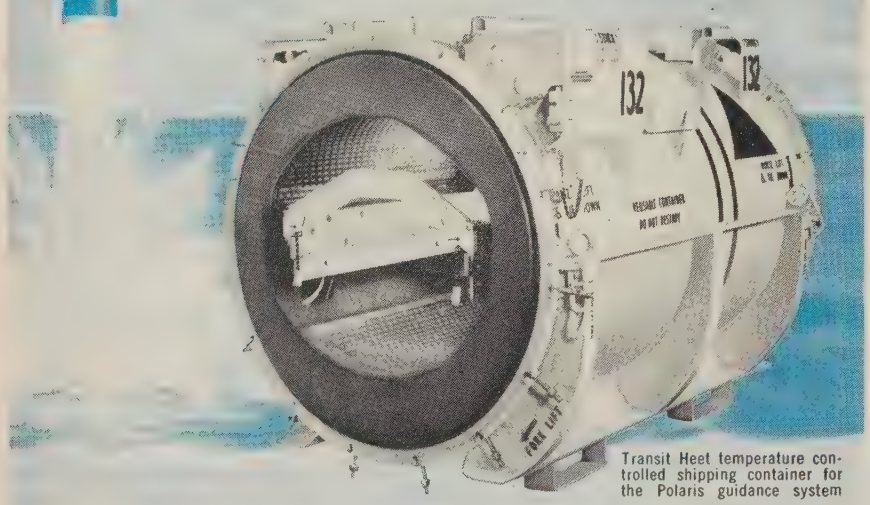
| **319,000** | — | **0.00042** | **YES** | " | **YES** |
| **387,000** | — | **0.00041** | **YES** | " | **YES** |
| **400,000** | — | **0.0004** | **YES** | " | **YES** |
| **375,000** | — | **0.0004** | **YES** | " | **YES** |
| — | — | — | **YES** | **Development Product** | **YES** |

## ASSURE RELIABILITY AND SAFETY

No. 210 on Reader Service Card

# Packaging the Polaris Brain

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A member of the NYTRONICS GROUP, an affiliate of NEFO


## Anc-App

Waterbury 20, Conn.

- SPECIALTIES—Flexible bronze, steel, stainless steel, Monel and Iconel metal hose and Teflon tubing for fueling systems in sizes ¼″ ID through 48″ ID; end fittings attached by heliarc welding, brazing, or mechanical means; insulated LOX lines, parts for vacuum jacketed cryogenic systems, gimbaled units, and assemblies for conveying new exotic fuels.
- CONTRACTS—Redstone and Jupiter-LOX fueling lines for Titan.
- LITERATURE—General Catalog (No. **1025** on Card), Flexible Metal Tubing For Expansion (No. **1026** on Card); Hose of Teflon (No. **1027 on Card).**
- CONTACT—E. M. Mierzwinski, Sales Engineer, PL 4-1121 Ext. 350.

**ANCHOR COUPLING CO., INC.,** 342 N. Fourth Street, Libertyville, Ill.

- SPECIALTIES—Rigid and flexible piping for hydraulically actuated GSE and special flexible high pressure long length hose assemblies for compressed gas missile servicing. Working pressures to 10,000 PSI.
- CONTRACTS—All hydraulic hose assemblies & fittings, M88 tank recovery vehicle, high pressure oxygen hose assemblies for Air Force vehicle, high pressure compressed gas hose assemblies for missile servicing.
- LITERATURE—Hose assemblies for ground support (No. **1028** on Card).
- CONTACT—R. E. Lyons, Chief Engineer.

**ANCHOR SPECIALTY MANUFACTURING CO. INC.,** 300 Hollister Rd., Teterboro, N. J.

- SPECIALTIES — Electro-Mechanical and Hydraulic Test Equipment Design and Fabrication.
- CONTRACTS—Subcontracts for Bendix and Kearfott Co.
- LITERATURE—Facilities list (No. **1029** on Card).
- CONTACT—William Zablocky, Pres., AT 8-1939.

**ANTLAB, INC.,** 6330 Proprietors Rd., Worthington, Ohio

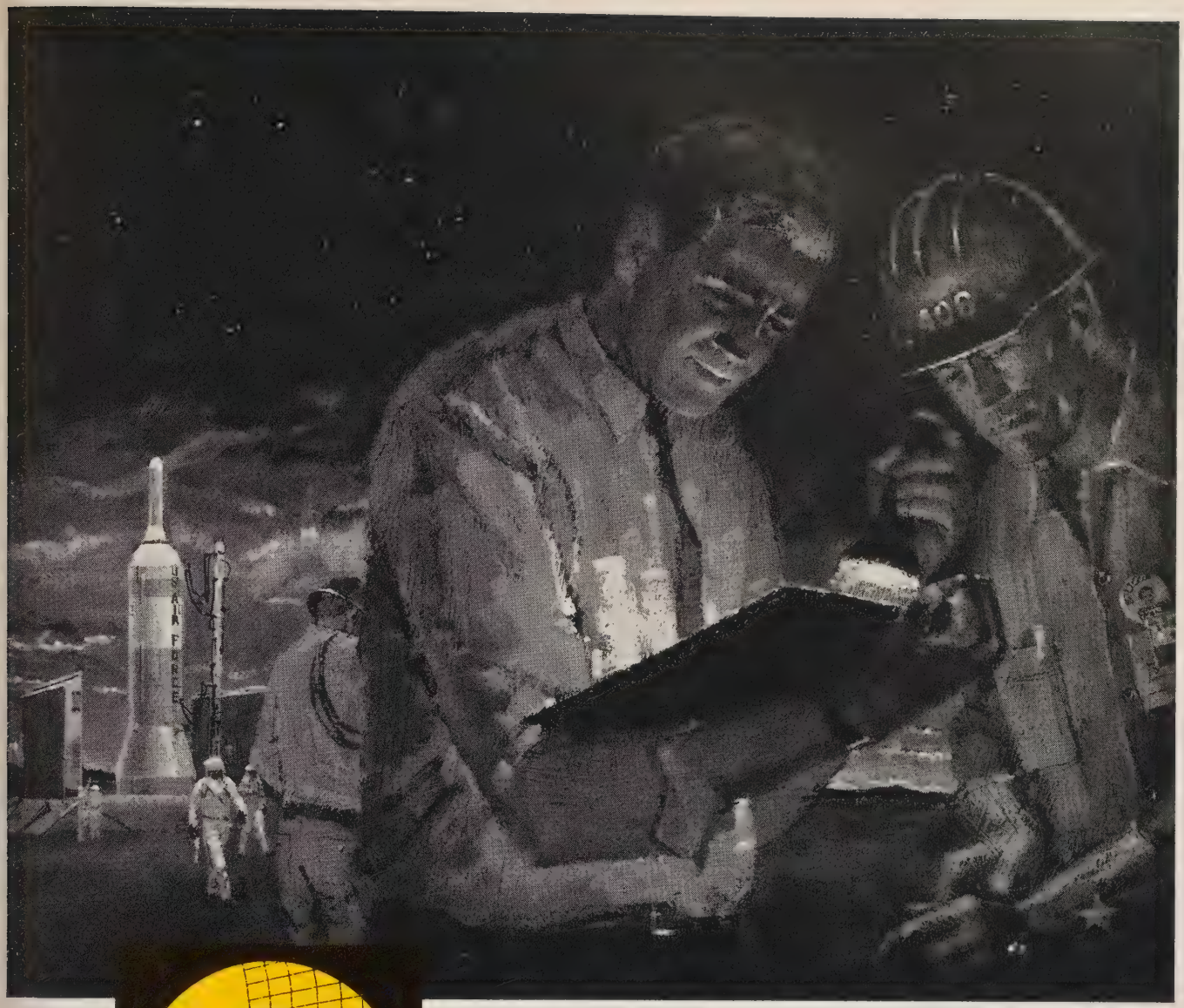
- SPECIALTIES—Design and production of antenna range instrumentation systems; missile tracking systems; servo-controlled pedestals; microwave receivers; polar, rectangular and flat-bed antenna pattern recorders; radome mounts; model support towers; pattern integrators; anechoic chambers.
- CONTRACTS—Prime contracts for the Army, Navy, and Air Force.
- LITERATURE—Catalog, 1961 (No. **1030** on Card); Equipment Data & Spec Sheets (No. **1031** on Card); Systems Brochure (No. **1032** on Card).
- CONTACT—Peter Pifer, Chief Engineer, TU 5-5396.

**APPLIED DESIGN CO.,** 2463 Sheridan Dr., Tonawanda, N. Y.

- SPECIALTIES—Shipping and storage containers, transporters, erectors, launchers and transit cases.
- CONTRACTS—Pershing missile,



No. 211 on Reader Service Card



**RESPONSIBILITY:** *RCA Project and Systems Management Teams*

**CAPABILITY:** *full support and integrated packages*

**APPLICATION:** *Major defense projects... USAF Titan ICBM, developed by The Martin Co.*

An *RCA Government Services* team takes full charge of organizational and field level maintenance for the launch complex of Titan operational base T-5 under subcontract to The Martin Company. This team of engineers and technicians will continue to provide vital support services until the site at Beale Air Force Base, Marysville, California, is operational.

*RCA Government Services* technical support and systems management groups work as a team with the armed forces, government agencies and prime contractors on many of the free world's high priority programs . . . including the Titan T-5 site, Atlantic Missile Range, BMEWS, White Alice, ComLogNet, and scores of others.

*RCA Government Services* offer vigor and versatility to meet the varied requirements and demands of complex project systems management. Contact the dynamic leader: *Government Services,* RCA Service Company, A Division of Radio Corporation of America, Camden 8, New Jersey.

RCA® The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA

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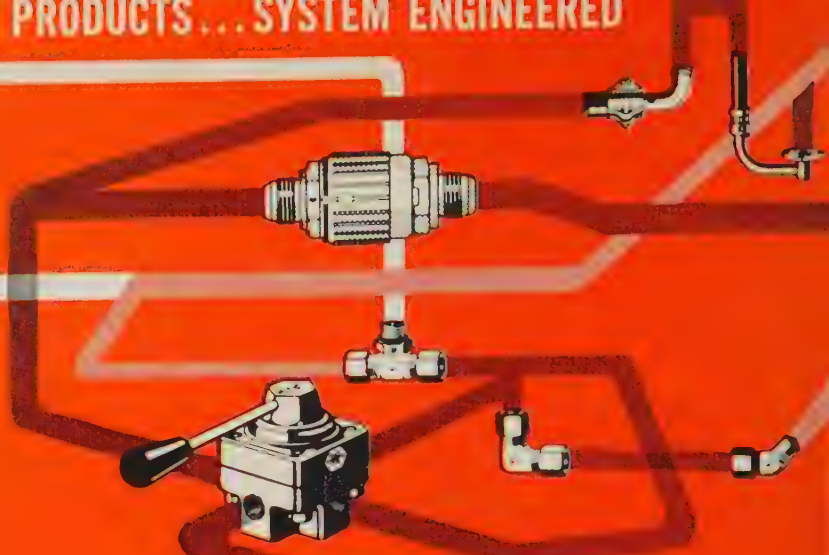
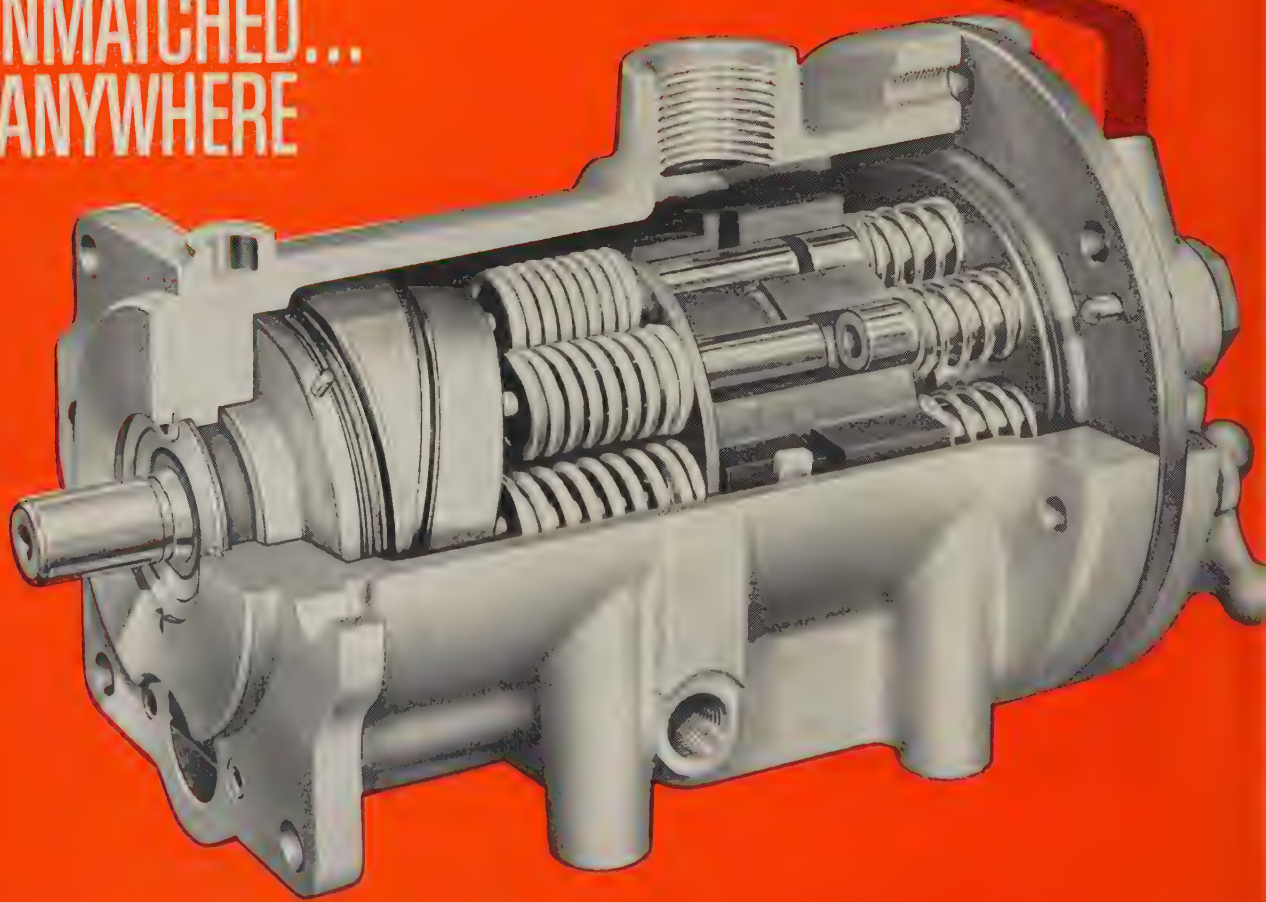
WEATHERHEAD FLUID POWER PRODUCTS . . . SYSTEM ENGINEERED

# NEW! WEATHERHEAD VARIABLE DISPLACEMENT HYDRAULIC PUMP UNMATCHED... ANYWHERE





**The new WO7 pump gives economy and performance advantages unmatched in high pressure, fluid power system applications. No other mass-produced, variable displacement hydraulic pump can now offer *all* these benefits:**

**INSTANT RESPONSE . . . hydraulically balanced, direct cylinder block actuation at lower power level without linkages.**

**PEAK EFFICIENCY . . . only two rotating parts; side loads on pistons minimized.**

**CONTROL VERSATILITY . . . pumping forces virtually eliminated from the displacement changing mechanism.**

**HIGH TEMPERATURE CAPABILITY . . . unique piston actuation permits fluids of low lubricity.**

**PUMP ECONOMY . . . size and weight are adaptable to a variety of applications; top reliability assured with no selective fits.**

**Pressure compensation control is provided as standa and integral part of the pump in adjustable press ranges from 250 psi to 3000 psi.**

**The WO7 pump incorporates J.I.C., S.A.E. and A.N design requirements for industrial and mobile appli tions; meets stringent requirements of military spe fications. Spline or keyway shafts are available.**

**Application and design data are available from y nearby Weatherhead sales engineer. Direct inquiries**

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HYDRAULICS AND PNEUMATICS

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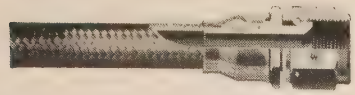
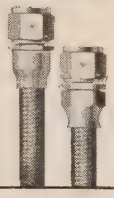
**WEATHERHEAD**
HYDRAULIC POWER
*Components*



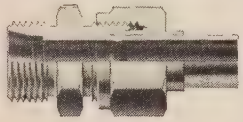
**TEFLON* HOSE**

Armor-plated hose assemblies, Braid-Lok permanent fittings and reusable fittings
*DuPont trademark



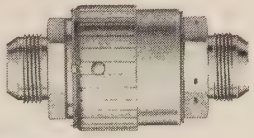
**MS (ER) FLARELESS FITTINGS**

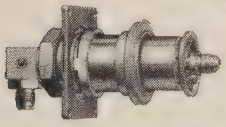
Superior Seal, Extreme resistance to vibration fatigue, Reusable



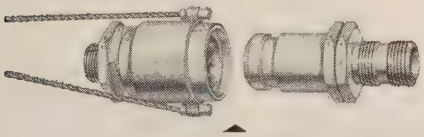
**QUICK DISCONNECT COUPLINGS**

Self-sealing, Positive locking, Straight through unrestricted flow





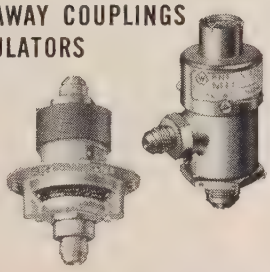
for liquid ammonia



"pull-away" coupling for missile launching

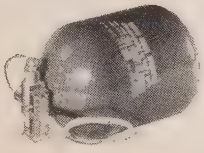
**BREAKAWAY COUPLINGS & REGULATORS**

For missile guidance system power and fuel system regulation



**PNEUMATIC VALVE & BOTTLE**

Explosive-actuated Provides power for missile guidance system



THE WEATHERHEAD CO.
*Products for the aviation and missile industry*
300 East 131 St. • Cleveland 8, Ohio
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Sergeant missile, and classified satellite (Eastman Kodak).
• LITERATURE—Brochure (No. **1033** on Card).
• CONTACT—H. E. Johnson, Chief Engineer, TF 6-9000.

**ARKWIN INDUSTRIES, INC.** 648 Main St., Westbury, N. Y.
• SPECIALTIES—Hydraulic and pneumatic components and systems, checkout equipment, fuel control equipment, environmental controls, fluid power supplies, actuation systems for launchers and hard sites.
• LITERATURE—General Products Brochure (No. **1034** on Card).
• CONTACT—E. Gravenhorst, V. P.-Sales & Eng., ED 3-2640.

**ARMA DIV., AMERICAN BOSCH ARMA CORP.,** Garden City, N. Y.
• SPECIALTIES—Automatic alignment, zeroing and checkout equipment with self check capabilities and memory units for operating inertial guidance stable platforms and checking airborne digital computers; trainers to provide a completely simulated set of GOE for training USAF personnel in operating and maintenance procedures.
• CONTRACTS—Alignment and checkout equipment for Atlas, Trainer T502 for Atlas.
• LITERATURE—GSE Becomes (of) Age (No. **1134** on Card); A Quick Look at Arma Age (No. **1135** on Card); General Arma GSE Capability (No. **1035** on Card.
• CONTACT—F. A. Rutz, Military Marketing, PI 2-2000.

**ARNOLT CORP.,** Argonne Rd., Warsaw, Ind.
• SPECIALTIES—Hydraulic systems testers, cabin leakage testers, motor torque testers; stationary in-plant bench testers and ground handling equipment; portable air conditioners.
• CONTRACTS—Cabin leakage tester for Boeing KC-135 and B-52, for Bomarc, and a 11.5-ton transportable air conditioner.
• LITERATURE—Facilities Brochure (No. **1807** on Card); Ground Support Brochure (No. **1036** on Card).
• CONTACT — H. M. Henderson, Vice President.

**ARROWHEAD PRODUCTS DIV., FEDERAL - MOGUL - BOWER - BEARINGS, INC.,** 4411 Katella Ave., Los Alamitos, Calif.
• SPECIALTIES—Manufacture and qualification of metallic, plastic, fabric, and insulated ducting systems; cryogenic insulations (evacuated shell or vacuum jacketed; ablation insulation lines; fuel handling suits.
• CONTRACTS—Self-contained atmosphere protective fuel handling suit for Titan; platform loading ducts and lanyard ducts for Atlas, stainless steel ducting force feed fuel loading system for Atlas, also ablation insulated lined model "E" launch system.
• LITERATURE—Insulation Systems Specs (No. **1136** on Card); Reinforced Plastics (No. **1137** on Card); Facilities Brochure (No. **1037** on Card).
• CONTACT—A. J. Dovey, Mgr., Applications Engrg., TA 8-7770.

**ASSOCIATED CO. INC.,** 1441 S. McLean Blvd., Wichita 13, Kan.
• SPECIALTIES — Electromechanical and mechanical erection and missile handling and transport system; mobile service equipment for fuel check out; preprogramed photograph, devices for recording missile trajectories.
• CONTRACTS—Stands for Mark IV re-entry vehicle, winch for Minuteman.
• LITERATURE—Brochure (No. **1038** on Card).
• CONTACT—W. F. Bowman, Development Section, HO 4-6379.

**ASTRODATA, INC.,** 240 E. Palais Rd., Anaheim, Calif.
• SPECIALTIES—Digital data acquisition and processing; time code generators, translators and tape search equipment; range timing operations centers; Signal conditioning and calibration systems for missile launch complexes.
• CONTRACTS—Automatic test subsystems for Atlas; signal conditioning system for Atlas; space vehicle test facility systems for Lockheed MSD.
• LITERATURE—Capabilities Brochure (No. **1138** on Card); Astrodata Reporter (No. **1139** on Card); Timing Equipment Catalog (No. **1039** on Card).
• CONTACT—W. E. Rianda, Pres., PR 2-1000.

**ATLANTIC RESEARCH CORP.,** Shirley Highway & Edsall Rd., Alexandria, Va.
• SPECIALTIES — Closed-breech launchers, and portable rail-type launchers.
• CONTACT—Robert Score, Sales Manager, FL 4-3400 Ext. 233.

**AUTOMATION DYNAMICS CORP.,** 255 County Rd., Tenafly, N. J.
• SPECIALTIES—Automatic test and checkout instrumentation, transistorized modules for sampling and display of analog or digital data for modules.
• CONTRACTS—Portable system for automatic test and checkout of electrical cables and connectors for Polaris.
• LITERATURE—Automatic Cable Test Set (No. **1140** on Card); Support Equipment Modules (No. **1040** on Card).
• CONTACT—Andy Sacco, Sales Mgr., LO 7-3232.

**AUTONETICS DIV., NORTH AMERICAN AVIATION, INC.,** 9150 E. Imperial Highway, Downey, Calif.
• SPECIALTIES — Programer-comparator and computer controlled checkout equipment for aircraft and missile systems; trainers and simulators for computer training and missile projects; ballistic missile, targeting and launch control consoles; telemetry.
• CONTRACTS—Automatic checkout and reporting system for Minuteman. Basic automatic checkout equipment for A-35, A-2f, W-2f aircraft, ACE equipment supplied to RCA for integra-

tion into APCHE equipment on Atlas.

• LITERATURE—BACE: Versatile Automatic Checkout Equipment (No. **1141** on Card); Verdan: Airborne Computer and Applications (No. **1041** on Card).

• CONTACT—Tom Davidson, Sales Engineer, PR 2-8111 Ext. 2603, 2604.

**AVCO CORP., ELECTRONICS & ORDNANCE DIV.,** Glendale-Milford Rd., Cincinnati, Ohio

• SPECIALTIES—Satellite receivers, codes and decodes, ground audio and digital codes, command receivers, and Ground and airborne communications.

• CONTRACTS — NASA satellite programs, VRC12 ground connection transmitter for army.

• LITERATURE—Satellite Receivers Codes and Decoders (Nov. **1042** on Card).

• CONTACT—Wells Chapin, Mgr., Marketry Communications, PR 1-8931 Ext. 548.

**AVCO CORP., NASHVILLE DIV.,** Box 210, Nashville 1, Tenn.

• SPECIALTIES—High strength-low bridge structures to increase mobility of military vehicles; armored vehicle launched bridge designs; and aerially emplaced bridge designs; portable military shelters.

• CONTRACTS — Avcomb (aluminum honeycomb) deck panels for test by Corps of Engineers.

• LITERATURE—Structural Properties of Avcomb (No. **1043** on Card).

• CONTACT—Henry Ritter, General Marketing Manager.

**AVDEL, INC.,** 210 S. Victory Blvd., Burbank, Calif.

• SPECIALTIES—Quick release pins for rapid assembly and material handling, ground safetying, lifting, tie-down, etc.

• CONTRACTS—Over 700 pins per launcher for Jupiter-C transportable launcher; tiedowns for Saturn.

• LITERATURE — Sales Brochure (No. **1142** on Card); Engineering Brochure (No. **1143** on Card); Ad Reprints (No. **1044** on Card).

• CONTACT—Russ Bremmer, VI 9-2331.

**AVIEN, INC.,** 58-15 Northern Blvd., Woodside 77, N. Y.

• SPECIALTIES—Handling, pumping, storage disposal, and temperature control of storable propellants and hydrogen peroxide; single antenna or multiple antenna interferometer types capable of self-tracking, self-acquisition, rapid rate, wide frequency band multichannel bi-polarized semi-hard antenna systems; electronic instruments and controls; photo reconnaissance, data processing and frequency surveillance systems.

• CONTRACTS — Broadband, high gain, tracking array for Alpha Corp., two loop tracking antennas and pedestals for proposed Nike-Zeus anti-missile missile Pacific test, processing system for Martin Co. to thermo decompose toxic vapors and liquids into gaseous products which are non-toxic in nature.

• LITERATURE — Antennas (No. **1144** on Card); Burner System Brochure (No. **1145** on Card); This is Avien Brochure (No. **1045** on Card).

• CONTACT—Frank DeNardo, Systems Marketing Manager, YE 2-4600.

**BALDWIN-LIMA-HAMILTON CORP., ELECTRONICS & INSTRUMENTATION DIV.,** Waltham 54, Mass.

• SPECIALTIES — Aircraft weight and balance with computer planner for loading, six components load cell for rocket motor test stands, high accuracy missile/silo weighing systems, load cell for rocket thrust determination, strain gage scanner recorder systems.

• CONTRACTS—Computer planner and CG systems for MATS cargo aircraft, six components for Polaris test stands.

• LITERATURE — Capabilities in Precision Force Measurement (No. **1146** on Card); Modern Force Measurement (No. **1147** on Card); E&I Division (No. **1046** on Card.

• CONTACT — Tracey Dickson, Manager, Applications Engineering.

**B & F INSTRUMENTS, INC.,** 3644 N. Lawrence St., Philadelphia 40, Pa.

• SPECIALTIES — Instrumentation such as strain gage and transducer input conditioning equipment, digital logging and plotting systems, and temperature calibrators.

• CONTRACTS — Countdown and preliminary flight data acquisition units for Atlas.

• LITERATURE — Facilities and Data Bulletin Folder (No. **1047** on Card).

• CONTACT—M. L. Stein, Sls. Mgr.

**BARBER-COLMAN CO.,** Rockford, Ill.

• SPECIALTIES—Temperature control systems for ground carts and missiles.

• CONTRACTS—Temperature control for Achiever guidance system (within few hundredths of one degree).

• LITERATURE—Condensed Product File (No. **1048** on Card).

• CONTACT—D. G. Kasper, Sales Coordinator, WO 8-6833.

**BARCO MANUFACTURING CO.,** 500 N. Hough Street, Barrington, Ill.

• SPECIALTIES — Design of pipe layouts incorporating ball or swivel joints for fuel, LOX, hydraulics, or pneumatic applications; missile base underground piping, sizes ¼″ to 16″ for normal and high temperature applications to +1200 deg F; specially designed stainless steel ball and swivel joints for pipe alignment, and thermal expansion and contraction; standard and specially designed hydraulic and pneumatic plane and self-aligning joints for mechanical movement; featherweight and standard LOX joints for thermal movement.

• CONTRACTS — Cryogenic ball joints for LOX fueling lines for Titan, 10″ gimbal and swivel assembly, and fuel line for Atlas missile erection.

• LITERATURE — Cryogenic Ball Joints (No. **1148** on Card); Hydraulic and Pneumatic Plane and Self-Aligning Swivel Joints (No. **1149** on Card); Standard Industrial Ball Joints for Normal and High Temperature Applications (No. **1049** on Card).

• CONTACT—J. H. Turner, Aircraft Div.

**BAUSCH & LOMB INC., MILITARY PRODUCTS DIV.,** 635 St. Paul St., Rochester 2, N. Y.

• SPECIALTIES—Optical, mechanical, and electronic engineering.

• CONTRACTS—Sun simulator for JPL space vehicle testing.

• LITERATURE — Sun Simulator Brochure (No. **1050** on Card).

• CONTACT—J. W. Wright, Contracts Manager, LO 2-3000, Ext. 52.

**BEATTIE-COLEMAN, INC.,** 1000 N. Olive St., Anaheim, Calif.

• SPECIALTIES — Electromechanical programers, Oscilloscope and data recording cameras.

• CONTRACTS—Ground checkout programer for Terrier on shipboard flight simulator, for Titan autopilot, for Polaris static tests.

• LITERATURE—Programer Technical Bulletin (No. **1051** on Card).

• CONTACT—J. A. Wilcox, V-P, PR 4-4503.

**BEAVER PRECISION PRODUCTS, INC.,** 651 N. Rochester Road, Clawson, Mich.

• SPECIALTIES—Linear actuating system for launch sites.

• CONTRACTS—Jacks for locking Titan pad to crib at silo, erection and positioning for Honest John, and others, door positioning for Saturn.

• LITERATURE—Screws and splines General Catalog (No. **1150** on Card); Commercial Screw and Spline Actuator Assemblies (No. **1151** on Card); Beaver Roller Way Bearings (No. **1052** on Card).

• CONTACT—J. A. Hope, V.P.-Sales, JO 4-6547 (Detroit.

**BECKMAN INSTRUMENTS, INC., SYSTEMS DIV.,** 2400 Harbor Blvd., Fullerton, Calif.

• SPECIALTIES — Missile engine checkout and data acquisition systems for both R&D and operational sites; telemetry data systems; wind tunnel systems; satellite communication and control systems; data translation and distribution systems; computer programming systems.

• CONTRACTS—Test facility system to search out and analyze Atlas missile deficiencies, data acquisition and data processing connected with engine test firings for Saturn and Pershing, Programmable Integrated Control Equipment (PICE) for Air Force satellite test center and two existing tracking stations.

• LITERATURE—210 Data Processing (No. **1152** on Card); Major GSE Systems Installation (No. **1153** on Card); GSE Applications (No. **1053** on Card).

• CONTACT—Frank Scheufele, Marketing Manager, TR 1-4848.

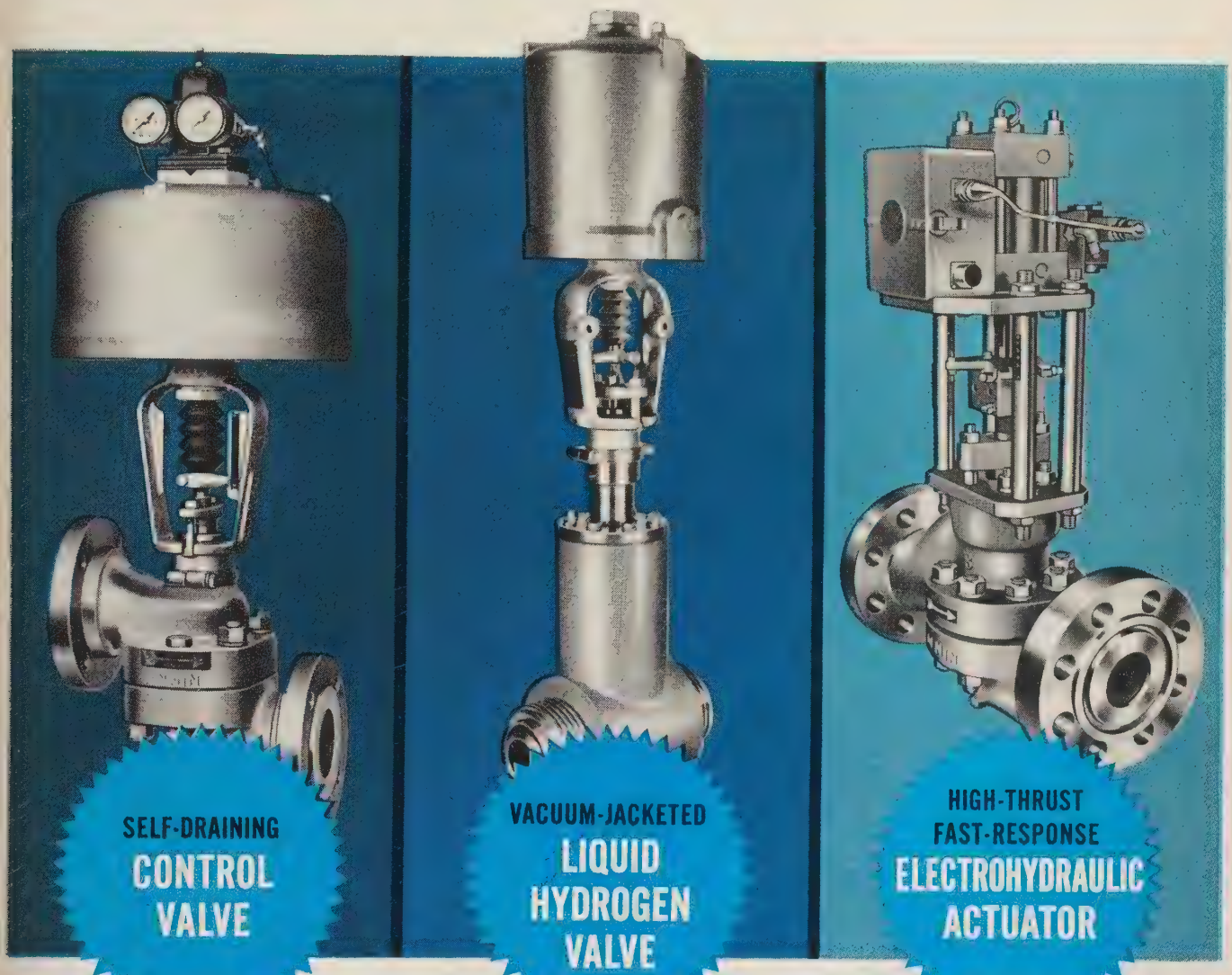
**BEECH AIRCRAFT CORP., AEROSPACE DIV.,** 9709 E. Central, Wichita, Kan.

• SPECIALTIES—Cryogenic ground handling transport and storage equipment; ground power units for starting jet aircraft and providing electrical power for radar units; jet aircraft checkout analyzers.

• CONTRACTS—Two types of semi-trailers for transporting fuel and oxidizer

# ANNIN VALVES ...offer advanced designs for fields that are moving ahead!

## *MILITARY AND PROCESS CONTROL APPLICATIONS*




In design and operational capability, Annin control valves begin where others leave off! The reason? Annin has always set the pace in fluid flow control ever since it pioneered split body, single seat construction, and showed control engineers how to achieve precise, positive control automatically. Typical of Annin's leadership today in fields requiring advanced design are the three new valves pictured above: Model 1900 Self-draining Control Valve, designed to handle toxic or corrosive fluids and slurries which must be flushed out of the system periodically; Model 1700 Vacuum Jacketed Cryogenic Valve, for the precise control of liquid hydrogen in missile ground support systems; and Series 20,000 Electrohydraulic Actuator, characterized by high thrust and extremely fast response, ideal for polyethylene reactor let-down valves, fuel blending systems, aero/space test stands, and with turbine by-pass valves for power plants.

*Send for complete technical bulletins on these and other Annin products*

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THE ANNIN COMPANY

1040 S. Vail Avenue • Montebello, California

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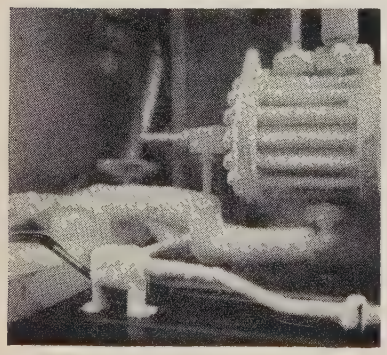
*cryogenics*

components and systems

- Pumps, vaporizers, subcoolers
- Tanks, tankers, rechargers
- Valves, liquid level switches, couplings
- Cryogenic samplers, NPSH meters, research dewars



*15,000 PSI Pump*

The Cosmodyne Corporation designs and manufactures a complete line of cryogenic ground support, airborne, and testing equipment. For complete information, send for Cryogenic Equipment Technical Data Brochure.

COSMODYNE

THE COSMODYNE CORPORATION
3232 WEST EL SEGUNDO BOULEVARD
HAWTHORNE, CALIFORNIA
OSBORNE 5-0327

No. 215 on Reader Service Card

See listings on Pages 39 & 70



for Titan II, topping control units for Atlas, and development of Albert Pod for B-70 to provide hydraulic and electric power.

• LITERATURE — Beechcraft Ground Support and Equipment (No. **1154** on Card); Cryogenics (No. **1155** on Card); Beechcraft Research and Development (No. **1054** on Card).

• CONTACT — R. H. McGregor, Mgr., Contract Admin., MU 3-4681.

**THE BENDIX CORP., ECLIPSE-PIONEER DIV.,** Teterboro, N. J.

• SPECIALTIES—Checkout equipment and adapters.

• CONTRACTS — AN/GJQ-9 checkout sequence programming set for Skybolt, line and depot automatic checkout testers for flight control and air data systems.

• LITERATURE—Universal Digital Module Test Set Brochure (No. **1156** on Card); Proven Automatic Checkout Brochure (No. **1157** on Card); AN/GJQ-9 Technical Data Sheet (No. **1055** on Card).

• CONTACT—J. M. Shirey, Sls. Mgr. AT 8-9450.

**THE BENDIX CORP., YORK DIV.,** York, Pa.

• SPECIALTIES — Automatically programmed missile test sets, radar simulators, missile simulators, data loggers, programmers.

• CONTRACTS — AW/DSM-60 Guided Missile Test Set for Talos.

**BORG-WARNER CORP.,** 200 S. Michigan Ave., Chicago 4, Ill.

• SPECIALTIES — Fuel control, ground support checkout, power systems, meteorological analysis, ground transport.

• CONTACT—S. J. Roush, Group Vice President, WA 2-7700.

**BROOKS PERKINS, INC.,** 1950 W. Fort St., Detroit 16, Mich.

• SPECIALTIES—Aluminum, magnesium, titanium and other lightweight materials with a high strength to weight ratio for missile loading and handling; all-magnesium vans for airborne control centers; air drop (aerial delivery) systems to support men in the field; "Boral" and other neutron shielding devices and fabrication.

• CONTRACTS—Missile handling tray for Talos, missile work platform for Jupiter, and electronics cabinets for Terrier.

• LITERATURE—Countdown Capabilities Brochure (No. **1158** on Card); Light Metals Data Brochure (No. **1159** on Card); GSE Precision Cabinets and Consoles (No. **1056** on Card).

• CONTACT—J. S. Kirkpatrick, Vice President, TA 5-5900.

**BROWN ENGINEERING CO., INC.,** Box 917, Huntsville, Ala.

• SPECIALTIES — Test, checkout, and calibration of hydraulic, pneumatic, and electrical assemblies, particularly special equipment used for reliability testing programs and final system checkout programs; control equipment for propellant handling systems and for launch facilities; development of design criteria and design of missile test facilities; design and modification of instrumentation vehicles.

• CONTRACTS—Fixtures for determining weight, center of gravity, and mass moment of Saturn booster, ground equipment test set for Saturn Launch Complex 34, and design and fabrication of swing arms for Saturn service tower.

• LITERATURE — Facilities Brochure (No. **1057** on Card).

• CONTACT—J. W. Hendrix, Chief Engineer, 536-5536, Ext. 218.

**BRUSH INSTRUMENTS DIV., CLEVITE CORP.,** 37th & Perkins, Cleveland 14, Ohio

• SPECIALTIES—Brush analog and operation recorders for automatic test, launch monitoring and data acquisition.

• CONTRACTS—Analog recorders for Polaris SINS navigation system and missile checkout; operations monitors for Titan guidance system checkout; analog recorders for Tiros "Quick-look" telemetry readout.

• LITERATURE—New Concepts in recording (No. **1058** on Card).

• CONTACT—D. E. Pierce, Mgr., Technical Services, EN 1-3365.

**BULOVA RESEARCH & DEVELOPMENT LABORATORIES DIV., BULOVA WATCH CO., INC.,** 62-10 Woodside Ave., Woodside 77, N. Y.

• SPECIALTIES—Automatic checkout equipment, simulators, launch monitoring equipment and trajectory data acquisition equipment; tactical field test equipment design and manufacture.

• CONTRACTS—Ground handling, test simulators, launch monitoring and control, launch and trajectory data acquisition, automatic checkout for Pershing, automatic test console and mechanical encoder test console for minuteman.

• LITERATURE—Ground Support Equipment & Special Test Equipment (No. **1808** on Card); Environmental Test Facilities (No. **1059** on Card).

• CONTACT—E. J. Misisco, Senior Project Engineer, NE 9-5700.

**BURNS & ROE, INC.,** 160 W. Broadway, New York 13, N. Y.

• SPECIALTIES — Design, fabrication, and installation of missile support facilities including assembly, servicing, and launchng equipment; architectural engineering services for anti-missile missile installations.

• CONTRACTS — Detailed mechanical, electrical, and civil engineering designs for world-wide Mercury sites and site facilities construction supervision; research, development, design, fabrication, installation, and testing of the Bomarc tactical protype ground support equipment, including missile assembly, servicing, and launching equipment, and all fixed facilities; architect-engineering services in designing test and prototype ground support facilities for Nike-Zeus.

• LITERATURE—Project Mercury (No. **1060** on Card).

**BURR-BROWN RESEARCH CORP.,** Box 6444, Tucson, Ariz.

• SPECIALTIES—Transistorized test instruments, operational and control amplifiers.
• CONTRACTS — Amplifiers for Ranger and Polaris programs.
• LITERATURE—Short form Catalog Sheet (No. **1160** on Card); Instrumentation Amplifiers (No. **1161** on Card); Modular Instruments (No. **1061** on Card).
• CONTACT — T. R. Brown, Jr. President, AX 8-0772.

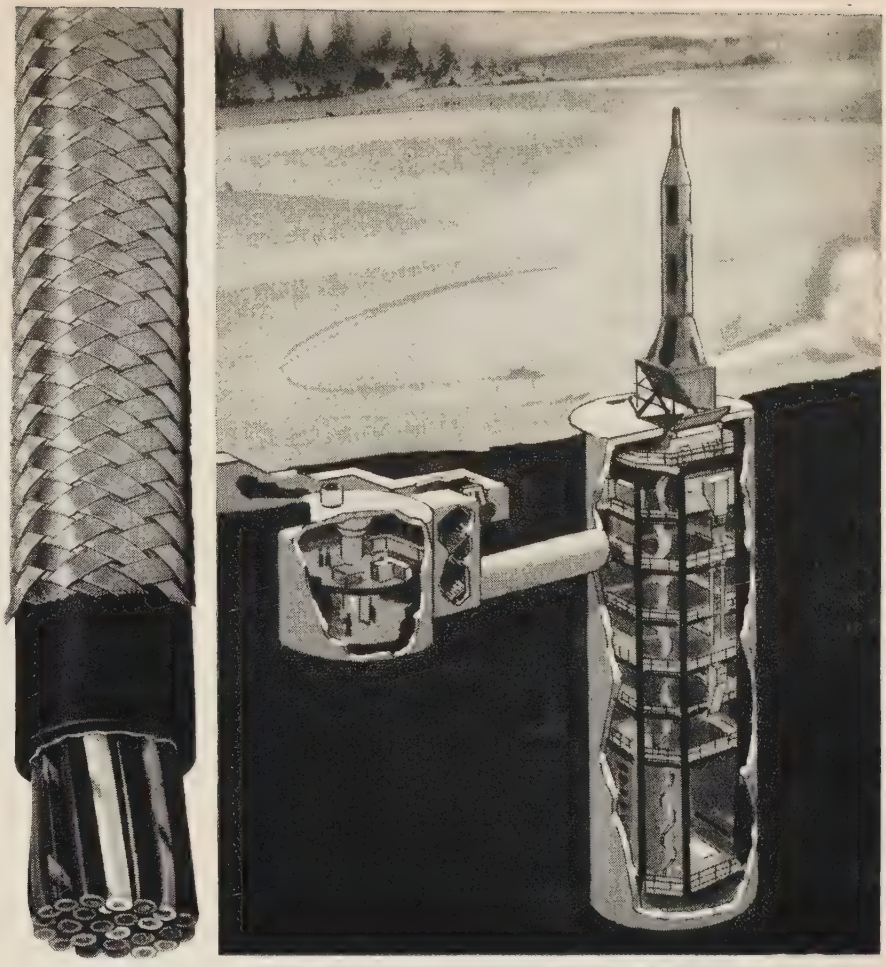
**BURROUGHS CORP., DEFENSE CONTRACTS ORGANIZATION,** 6071 Second Ave., Detroit 32, Mich.
• SPECIALTIES — Data processing and command and control systems, automatic checkout equipment, training aids, radar simulators.
• CONTRACTS—Atlas ground guidance and range safety computer for Atlantic and Pacific Missile Ranges, stabilization data computer for Polaris submarine periscope and radiometric sextant, ground based AN/FST -2 and airborne AN/AYQ -1 to reduce and interpret large volumes of raw radar data to digital form for transmission to SAGE Direction Center.
• LITERATURE — Atlas Missile Ground Guidance System (No. **1162** on Card); Polaris Stabilization Data Computer (No. **1163** on Card); Sage AN/FST-2 Data Processor (No. **1062** on Card).

**BYRON JACKSON PUMPS, INC.,** Box 2017, Terminal Annex, Los Angeles 54, Calif.
• SPECIALTIES—Centrifugal pumps for liquid oxygen and jet fuel.
• CONTRACTS—Fuel handling and liquid oxygen system for Saturn lower and upper stages, liquid oxygen handling for Jupiter.
• LITERATURE—Cryogenic pumps (No. **1164** on Card); SMJ & SMJI Process Pumps (No. **1063** on Card).
• CONTACT—E. Baldoni, Chief Estimating Eng., LU 7-6171.

**CARDAIR DIV., MARMON-HERRINGTON CO., INC.,** 510 Indianapolis Ave., Lebanon, Ind.
• SPECIALTIES—Central High pressure pneumatic Compression System; helium, nitrogen, air storage systems; purification equipment; valves, fittings, and steel line.
• CONTRACTS — Mobile helium compressors for Atlas, central helium compression systems for Titan.
• LITERATURE — Cardair Catalog (No. **1165** on Card); Data Sheets (No. **1064** on Card).
• CONTACT—W. J. Simons, Sales Engr., 3360.

**CARDOX DIV. CHEMETRON CORP.** 840 N. Michigan Ave., Chicago 11, Ill.
• SPECIALTIES—Bulk liquid carbon dioxide and dry ice storage units; distribution equipment; carbon dioxide vapor recovery devices.
• LITERATURE — Environmental Testing Brochure (No. **1065** on Card).
• CONTACT—R. R. Moore, Genl. Sls. Mgr., WH 4-7450, Ext. 8, 9.

**CARMODY CORP.,** 2361 Wehrle Dr.,

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Rockbestos ground support cable meets and conforms to all requirements of MIL-C-13777-C.

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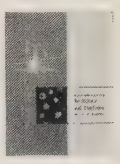

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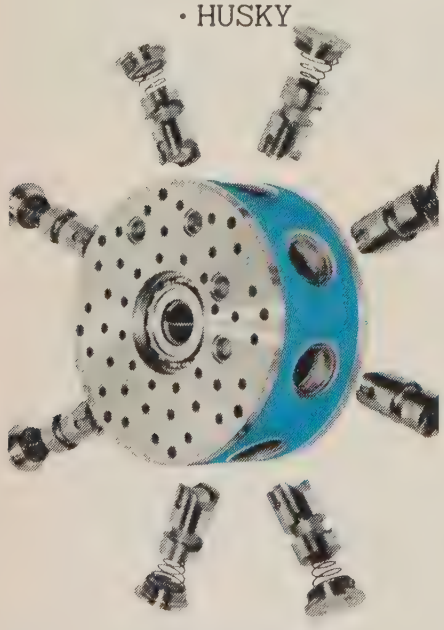

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Buffalo 21, N. Y.
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• CONTACT—J. A. Banzhaf, V.P.-Engineering, NF 3-7700.

**THE J. C. CARTER CO.,** 671 W. 17th St., Costa Mesa, Calif.
• SPECIALTIES—High flow cryogenic pumps and pumping systems, canned motor pumps for exotic fuels and nuclear applications, development of special valves and regulators including high pressure solenoid and check valves.
• CONTRACTS—All liquid oxygen unloading pumps on Titan 1; all canned motor pumps for Titan II unloading, UDMH/hydrazine, nitrogen tetroxide; 6000 gpm liquid oxygen loading system developed for Edwards.
• LITERATURE—Cryogenic Pump Brochure (No. **1166** on Card); Solenoid and High Pressure check Valve Data Sheets (No. **1066** on Card).
• CONTACT—W. W. Saxton, Sls. Mgr., LI 8-3421.

**CATALYTIC CONSTRUCTION CO.,** 1528 Walnut St., Philadelphia 2, Pa.
• SPECIALTIES—Installation, operation and maintenance of weapon system equipment for primes.
• CONTRACTS—Bomarc, Atlas.
• CONTACT—A. P. Klopp, v-p Sales, KI 5-7500.

**CATERPILLAR TRACTOR CO., DEFENSE PRODUCTS DEPT.,** Peoria, Ill.
• SPECIALTIES — Wheel or track transport and work vehicles with particular emphasis on off-road mobility; precise diesel power generator electric sets; power trains, power control systems and vehicle structures.
• CONTRACTS—Development contract for a floatable high speed transporter with off-road mobility, development contract for a 675-HP aluminum engine, feasibility study of diesel and/or gas turbine combination for prime power.
• LITERATURE—To Develop New Concepts (No. **1067** on Card).
• CONTACT—F. S. Foster, Mgr., Sls. Div., 676-3311 Ext. 5-650.

**CENTURY ELECTRONICS & INSTRUMENTS, INC.,** 1333 N. Utica, Tulsa 10, Okla.
• SPECIALTIES—Capabilities data acquisition and recording equipment plus integral systems for checkout of missile components at launch site; constant current supplies accelerometer vibration checkout tools; pressure transducer calibration system; digital voltmeters and printers.
• CONTRACTS — Telemetry checkout cart for major ICBM, stationary and vehicle borne recording systems and pressure switches for other missiles, transport recorder for major ICBM.
• CONTACT—H. D. Bissell, Mgr., Field Engr. & Customer Service, TU 1407.

**THE CERAND CORP.,** 285 Columbus Ave., Boston 16, Mass.
• SPECIALTIES—Civil engineering construction supervision, highway and rail transportation, vulnerability studies, construction specifications and special civil engineering problems, site and pad facilities design.
• LITERATURE — Capability Brochure (No. **1068** on Card).
• CONTACT—John Clarkson, President, CO 6-7720.

**CHRISTIE ELECTRIC CORP.,** 3410 W. 67th St., Los Angeles 43, Calif.
• SPECIALTIES — Precision d-c power for automatic checkout equipment; trainer and test simulators and launch monitoring and control; automatic battery chargers for nickel-cadmium and silver-cell batteries.
• CONTRACTS—DC power supplies for ground checkout equipment for Minuteman, silver-cadmium battery chargers for Minuteman, shipboard power for Polaris pre-launch checkout.
• LITERATURE—Silicon Rectifier Power Supplies (No. **1167** on Card); Automatic Battery Chargers (No. **1168** on Card); Universal Battery Charger (No. **1069** on Card).
• CONTACT—Fred Benjamin, Mgr., Industrial Sales, PL 0-1151

**CHRYSLER CORPORATION, DEFENSE GROUP,** Box 757, Detroit 31, Mich.
• SPECIALTIES — Fully integrated development and production, launch control units, electrical power units, fault isolation units, guidance and control test units, propellant transfer units, power distribution units, transporters and erectors; electro-optical alignment and aiming devices; cryogenic propellant handling; ground handling transport, erectors and launchers; van trailers and flat bed trailers; cooling equipment.
• CONTRACTS—Weapons system ground support equipment for Redstone and Jupiter, electro/optical alignment devices (twist autocollimator) for mobile Minuteman, shipboard missile test set for Polaris.
• LITERATURE—8 Ton Tactical Military Truck (No. **1169** on Card); 2½ Ton Tactical Military Truck (No. **1070** on Card).
• CONTACT—C. W. Snider, Director, Government Relations, JE 9-3000.

**CIMTROL DIV., THE CINCINNATI MILLING MACHINE CO.,** Cincinnati 9, Ohio.
• SPECIALTIES—Hydraulic motors for servo drives, electro-hydraulic servo valves.
• CONTRACTS — Hydraulic motor drives for Haystack antenna.
• LITERATURE—GSE Drive Bulletin (No. **1448** on Card).
• CONTACT—W. H. Bentley, Mgr., Mkt. Dev.

**COHU ELECTRONICS, INC., KIN TEL DIV.,** 5725 Kearny Villa Rd., San Diego 12, Calif.
• SPECIALTIES—Closed circuit television systems, digital voltmeter.
• CONTRACTS — CCTV cameras, control units, and monitors for Atlas fueling observation and general surveillance of launch pad; CCTV cameras, control units and monitors in and around Titan silos; for MACE checkout digital voltmeter.
• LITERATURE—TV System Plan-

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ning Chart (No. **1170** on Card); Bird-watching in Wyoming (No. **1171** on Card); Militarized Digital Voltmeter (No. **1071** on Card).

• CONTACT—E. T. Clare, Vice President-Marketing, BR 7-6700.

**COMPUDYNE CORP.,** 400 S. Warminster Rd., Hatboro, Pa.

• SPECIALTIES — Instrumentation systems for launching sites and test facilities.

• CONTRACTS—Propellant loading, purging and venting control and alarm systems for Titan I, instrumentation and control system for Atlas propellant loading and unloading, testing stands for production checkout of Bomarc auxiliary power units, fuel pumps and power supplies.

• LITERATURE — Capabilities of CompuDyne Corporation (No. **1172** on Card); Typical Contracts Brochure (No. **1173** on Card); Facilities Data (No. **1072** on Card).

• CONTACT—H. A. Lucas, Corporate Contracts Manager, OS 2-1400.

**CONSOLIDATED AVIONICS CORP.,** 800 Shames Dr., Westbury, N. Y.

• SPECIALTIES—Automatic circuit analyzers, strain gauge processing system; automatic testing and calibration systems; automatic digital steady state data-taking system; telemetry data monitors; digital testers; power supplies, AC field test units, control computer test sets, Valve Testers, etc.

• CONTRACTS—Automatic circuit analyzer for Lockheed aircraft, automatic digital steady state data-taking system for Boeing Co.

• CONTACT—William Perzley, Vice President-Engrg., ED 4-8400.

**CONSOLIDATED DIESEL ELECTRIC CORP.,** 880 Canal St., Stamford, Conn.

• SPECIALTIES — Special purpose and multi-purpose vehicles including fuel handling tank trucks; demineralized water tank trucks; fuel decontamination and metering trailers; aircraft tractors; nose-cone handling dollies; self-powered aircraft spotting dollies; self-propelled electric, hydraulic and pneumatic power plants; vans, trailers and shelters including mobile bio-medical facility, altitude chamber, machine shop, instrumentation unit and power plant; gas turbine-driven power packs including air-cycle refrigeration and air conditioning units; engine-driven uninterrupted power supplies, engine-generator sets, multi-voltage generators.

• CONTRACTS—R-2 aircraft refueling tank trucks for USAF; MB-2 aircraft towing tractor for USAF; MH-2A fuel service cart for USAF.

• LITERATURE—Aircraft Towing Tractor (No. **1174** on Card); Power Without Interruption; Mobile Shelters (No. **1073** on Card).

• CONTACT — Edward Gomberg, General Sales Manager, DA 5-2261.

**CONSOLIDATED SYSTEMS CORP.,** 1500 S. Shamrock Ave., Monrovia, Calif.

• SPECIALTIES — Propellant handling valves and control systems; pneumatic test set trailers; automatic checkout equipments for weapons systems; satellite ground support systems analog data acquisition, reduction, conversion, presentation, analysis; digital data generation, processing presentation, translation, precision pressure systems for generation, measurement, calibration, control; wave analyzing systems, including systems for power spectral density analysis.

• LITERATURE—Mobilized Missile Ground Support Equipment (No. **1175** on Card); Microsadic Data Acquisition System (No. **1176** on Card); Satellite Mass Spectrometer (No. **1074** on Card).

• CONTACT—A. B. Dallas, Director, Field Engrg., EL 9-9111.

**CONSOLIDATED VACUUM CORP.,** 1775 Mt. Read Blvd., Rochester 3, N. Y.

• SPECIALTIES—On-site construction facilities for installations of space test chambers, and vacuum equipment; R&D facilities for development of advanced vacuum techniques and pumping systems.

• CONTRACTS—Subcontracts for Lockheed, Jet Propulsion Laboratory, and General Electric.

• CONTACT—Max Garber, Vice-President-Marketing.

**CONSOLIDATED WESTERN STEEL DIV., UNITED STATES STEEL CORP.,** Box 2054, Terminal Annex, Los Angeles 54, Calif.

• SPECIALTIES — Ground support and handling facilities, electrical and hydraulic design, testing packaging, shipping and erecton of production.

• CONTRACTS—Production design and fabrication launchers for Nike-Hercules, fabrication of launchers for Atlas, fabrication of underwater platforms and camera towers for Polaris.

• CONTACT—R. Ritchey, Manager, Aircraft & Missile Div.

**CONTROL DATA CORP.,** 501 Park Ave., Minneapolis 15, Minn.

• SPECIALTIES—General purpose solid state electronic digital computers, computer programming engineering systems assistance at proposal stage at no cost to prime bidder.

• CONTRACTS—Ground data collection computer for Midas and Discoverer, geoballistic fire control computers for Polaris II system, ground computers for Nimbus weather satellites.

• LITERATURE — Ground Based Computers (No. **1177** on Card); Airborne & Field Computer (No. **1178** on Card); Control Data Space Computer Interim Report (No. **1075** on Card).

• CONTACT—G. S. Hanson, Director of Marketing, FE 9-0411.

**CONTROLS CO. OF AMERICA, CONTROL SWITCH DIV.,** 4218 W. Lake St., Chicago 24, Ill.

• SPECIALTIES—Man machines interface equipment including manually operated switches, indicator lights, electroluminescent display devices and modular panel presentations.

• LITERATURE — Electroluminescence Catalog (No. **1179** on Card); Alpha Numeric Digital Readout (No. **1180** on Card); Multi-Station Switch Assemblies (No. **1076** on Card).

• CONTACT—Robert Provart, Director.

**CONVAIR - GENERAL DYNAMICS CORP.,** San Diego, Calif.

• SPECIALTIES—A&E design service oriented to the design of special GSE facilities equipment; liquid propellant fueling systems, aircraft missiles, space vehicles, ground handling equipment, missile and space vehicle launchers and erectors, mobile and facilities type-integrated rapid automatic checkout systems, system and subsystem trainers and simulators including total weapon systems analysis for requirements, design of complete launch control complex including land lines installation, data instrumentation and telemetering systems, cryogenic handling for missile and space vehicle systems and space environmental facilities, missile launch ground power control and distribution systems.

• CONTRACTS — Erector and launcher combination for Atlas with feed-thru service connection engine run-up hold down, and launch release mechanism; R&D electrical launch control systems design & validation responsibility for Atlas test sites and space booster sites. (Mercury, Agena Ranger, Centaur); hard vacuum of $10^{-14}$ Hg for General Dynamics.

• LITERATURE—Convair's Engineering Support for Your Design Problems (No. **1077** on Card).

• CONTACT—C. S. Brandt, Chief, Product Support Design, Mail Zone 6-114.

**COOK ELECTRIC CO.,** 2700 N. Southport Ave., Chicago 14, Ill.

• SPECIALTIES—Magnetic recording systems and computer peripheral equipment; engineer, install, train personnel for, and manage complete communication networks for hardsite bases; space vehicle recovery systems and related ground-support systems and sub systems; environmental chambers; custom built ground support and test equipment including installation of nuclear test equipment.

• CONTRACTS—Digital magnetic tape recorders for Polaris, dynamic analyzer for Minneapolis Honeywell that simulates simultaneously many diverse environments; design and instrument Orbiting Astronomical Observatory for U. of Wisconsin (Wash.).

• LITERATURE — Turnkey Communications (No. **1181** on Card); Nucledyne Aerospace GSE Brochure (No. **1182** on Card); Achievements (No. **1078** on Card).

• CONTACT—Gerald Cannon, Dir., Public Relations, DI 8-6700.

**THE COOPER-BESSEMER CORP.,** Mount Vernon, Ohio.

• SPECIALTIES—Diesel, gas and fuel engines generators to supply precise electrical power, reciprocating expansion engines.

• CONTRACT—1500-kw diesel engine generator sets for Nike-Zeus acquisition radar; expansion engines for production of liquid nitrogen and oxygen.

• LITERATURE—LSV Engine Bulletin (No. **1079** on Card).

• CONTACT—R. L. Spetka, Mgr., Engine Sales, EX 3-0121.

**COSMODYNE CORP.,** 3232 West El Segundo Blvd., Hawthorne, Calif.

• SPECIALTIES — Cryogenic liquid storage and transport equipment includ-

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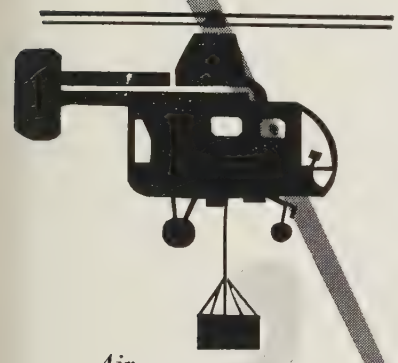

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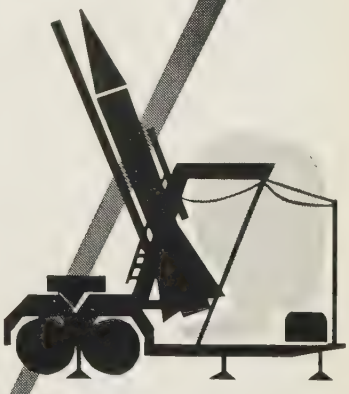
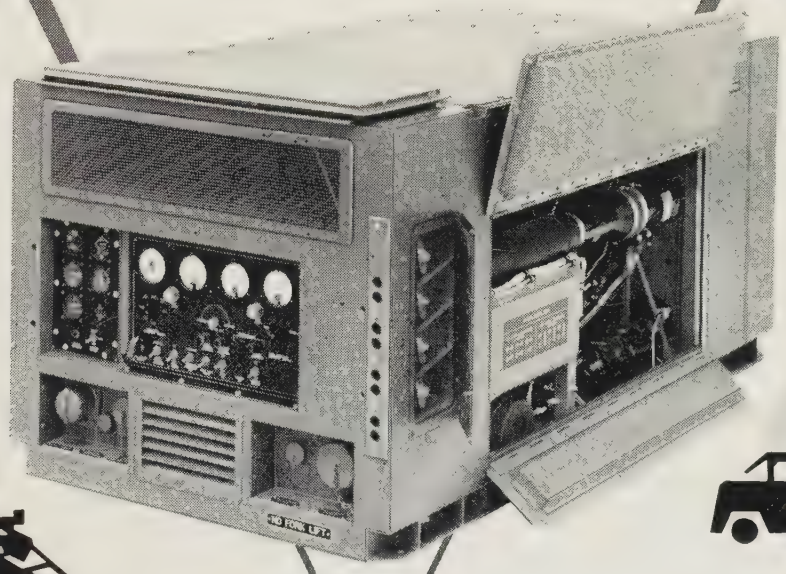


*Missile support*



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## Inputs from BMEWS Provide Instantaneous Missile Data Direct to NORAD Headqu

From our vast outer defense perimeter, over thousands of miles, to the nerve center of the North American Air Defense Command at Colorado Springs, the most advanced concept of data handling and checkout is being utilized in the BMEWS system. The stakes are high, for the purpose is defense of the North American Continent.

At BMEWS installations operated by USAF Air Defense Command, computers read out missile tracking data from giant radars. This information is simultaneously relayed to NORAD's Combat Operations Center.

The Radio Corporation of America is prime systems contractor for BMEWS. At the COC, RCA's Display Info Processor computing equipment automatically evaluate sightings, launch sites and target areas. By means of da essing and projection equipment installed by RCA and a other electronics manufacturers, the findings are disp huge, two-story high map-screens in coded color symb viding the NORAD battle staff with an electronic p of the North American and Eurasian land masses.

The handling of BMEWS inputs at NORAD is an ex how RCA data processing capabilities are assuring the gree of reliability so vital to continental defense.

...adquarters, RCA computing equip-
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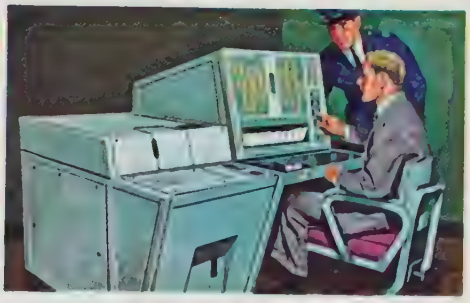
shown here) receives sightings data from
and processes it for automatic readout.

RCA is prime system contractor for the sprawling BMEWS three-site radar network whose probing electronic fingers reach deep into space to provide early warning of missile attacks.



RCA's Automatic Checkout & Monitoring equipment continuously tests and checks performance of portions of the system and alerts an operator when a monitored signal exceeds certain limits

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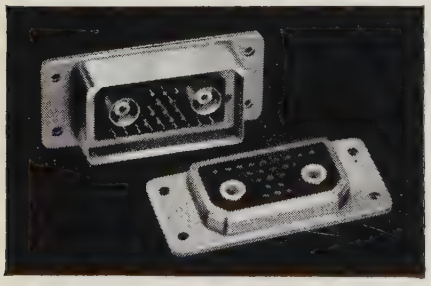

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• CONTRACTS — Cryogenic GSE; tankers, pumps, rechargers, lox clean testing for Atlas, cryogenic GSE; tankers, pumps and rechargers for Titan, cryogenic liquid quality control samplers for Air Force.

• LITERATURE—Cryogenic Equipment Technical Data Folder (No. **1183** on Card); Cryogenic Equipment Brochure (No. **1184** on Card); Cryogenic Pump Application and Data Folder (No. **1080** on Card).

• CONTACT—J. L. Hoch, Vice President, Marketing, OS 5-0327.

**CRYOGENIC ENGINEERING CO.,** 200 W. 48th St., Denver 16, Colo.

• SPECIALTIES—Production, handling and transportation of liquid hydrogen.

• LITERATURE — Cryogenic Data Cards (No. **1710** on Card). Liquid Hydrogen Cryovalves (No. **1711** on Card); Liquid Hydrogen Transfer Lines (No. **1712** on Card).

**CRYOQUIP CORP.,** 2400 E. Imperial Blvd., Lynwood, Calif.

• SPECIALTIES—Cryogenic tankage, tankers, rechargers, and converters; stainless and carbon steel heavy fabrication; fuel handling equipment, tankers, and systems; process heat exchangers and lox cleaning of process systems.

• CONTRACTS—Cryogenic tankers, rechargers and lox cleaning for Atlas; cryogenic tankers and rechargers for Titan; cryogenic handling equipment for Air Force.

• LITERATURE—Cryogenic Equipment Technical Data Folder (No. **1185** on Card); Cryogenic Equipment Brochure (No. **1186** on Card); Cryogenic Tankage Sheets (No. **1081** on Card).

• CONTACT—J. L. Hoch, Vice Pres., Marketing, OS 5-0327.

**CRYOTHERM INC.,** Fogelsville, Pa.

• SPECIALTIES—Precision thermodynamics systems, heat storage and control, automatically programmed low-temperature test chambers, independent temperature stabilized shipping and storage of ultra-delicate instruments, rigid and flexible molded polyeurethane foam (to spaces).

• CONTRACTS — Subcontracts for Polaris I and II, Mace.

• LITERATURE — Company Brochure (No. **1709** on Card).

• CONTACT—J. D. Wilson, AT 5-4811.

**DALMO VICTOR CO.,** 1515 Industrial Way, Belmont, Calif.

• SPECIALTIES—Antenna checkout equipment including mechanical alignment, RF boresight test, high power test, electro-mechanical and servo test equipment; three axis flight simulators.

• CONTRACTS—RF boresight test set for B-52 Bomb/Nav system, antenna checkout equpment for F-104 and F-105 fire control radar, flight simulator for Polaris guidance system.

• LITERATURE — GSE Brochure (No. **1187** on Card); System Spectrum Brochure (No. **1082** on Card).

• CONTACT—E. W. Carroll, Sls. Mgr., LY 1-1414.

**DATA INSTRUMENTS DIV. TELE-COMPUTING CORP.,** 12838 Saticoy, North Hollywood, Calif.

• SPECIALTIES—Data reduction and real time data acquisition systems.

• CONTRACTS—Tape perforators for Minuteman; data reduction system for Saturn.

• LITERATURE—Transducer Equalizer (No. **1188** on Card); Tape Perforator and Reader (No. **1189** on Card); High Precision Shaft Encoder (No. **1083** on Card).

**DAVENPORT MANUFACTURING DIV., DUNCAN ELECTRIC CO., INC.,** 2532 N. Elston Ave., Chicago 47, Illinois.

• SPECIALTIES—Testing equipment, power supplies, insulation resistance measurement.

• CONTRACT—Power supplies and test instrument subcontractor to MIT, NAA, STL.

• LITERATURE — Power Supplies (No. **1190** on Card); HV Test Equipment and Instruments (No. **1191** on Card); Testing Equipment for Underground Cables (No. **1084** on Card).

• CONTACT — D. A. Davenport, Gen. Mgr., DI 2-5620.

**DAVIDSON OPTRONICS, INC.,** 2223 Ramona Blvd., West Covina, Calif.

• SPECIALTIES—Electro-optical instruments for monitoring and aligning guidance platforms at missile launch; laboratory instruments are also used for aligning and checking platform optics, hydrodynamic balances for calibrating gyros; large optics and mounts for astrometric telescopes to photograph and observe the progress of deep space probes and artificial satellites.

• CONTRACTS—Optics for 60 in. astro telescope for the Navy; reconditioning contract on long range electrotheodolites for Thor; closed circuit TV optical alignment system for Sergeant.

• LITERATURE—Product Brochure (No. **1192** on Card); Instrument Spec Sheets (No. **1085** on Card).

• CONTACT—James McBride, Gen. Mgr. ED 7-7281.

**DAYSTROM, INC., CONTROL SYSTEMS DIV.,** 4455 Miramar Road, La Jolla, Calif.

• SPECIALTIES—Solid state digital computer systems and digital techniques for automatic checkout; peripheral equipment such as D.C. amplifiers, sensitive control relays, A/D and D/A converters and specialized analyzers; solid state components and systems for monitoring and alarming of temperatures, pressures and flows etc. on low levels never before possible.

• CONTRACTS—Current comparators for monitoring and control of LOX and fuel pressure on Atlas, one-third octave wave analysis system for Polaris subs, solid state control relays for low level millivolt resistance monitor and alarm on Minuteman.

• LITERATURE—Solid State Detection Device (No. **1193** on Card); Control

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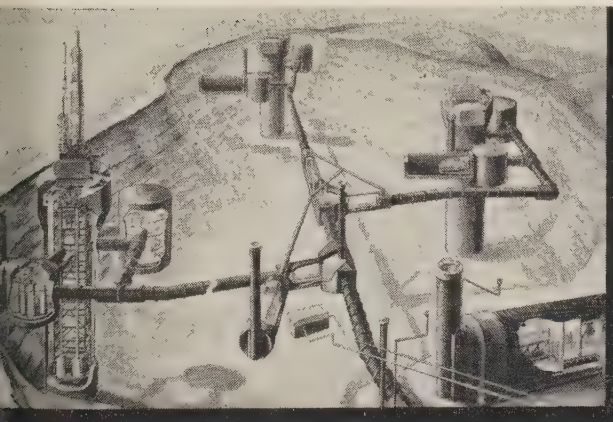

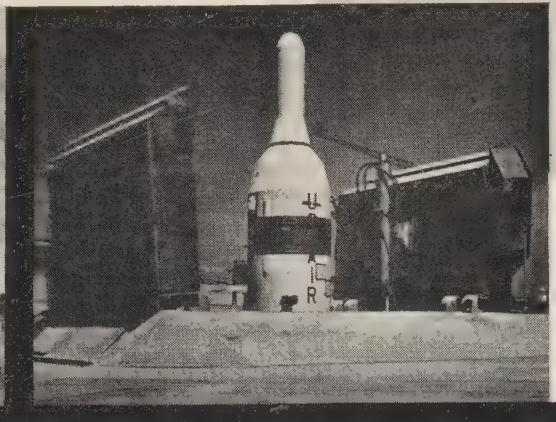

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Relay (No. **1194** on Card); Micro-Alarm (No. **1086** on Card).

• CONTACT—J. M. Warner, Sls. Mgr., Products, GL 4-0421.

**DAYSTROM, INC., MILITARY ELECTRONICS DIV.,** Archibald, Pa.

• SPECIALTIES—Radar test and equipment; tactical and team training devices and simulators for ASW and missile fire control systems; high speed main memories, buffers and terminal data handling equipment; solid state instrumentation for nuclear reactors and primary power plants.

• CONTRACTS—Checkout equipment for B-70 navigational and bombing radar system and analog servo systems; digital terrain display for pilot training; status display for Polaris.

• CONTACT—J. C. Quinn, Director, R&D, 876-1500, Ext. 591.

**DAYSTROM WIANCKO ENGINEERING CO.,** 255 N. Halstead Ave., Pasadena, Calif.

• SPECIALTIES — Instrumentation systems for data acquisition and processing; transducers for dynamic measurement; test and calibration instrumentation.

• CONTRACTS—Remote pressure indicators for Pratt and Whitney Aircraft Company, secondary standards for Arnold Engineering and Research Center.

• LITERATURE — Company Capabilites (No. **1195** on Card); Digital Pressure Generator Bulletin (No. **1196** on Card); DC Pressure Transducers Bulletin (No. **1087** on Card).

• CONTACT—J. W. Allen, Mgr., Technical Services.

**DEMORNAY-BONARDI,** 780 S. Arroyo Parkway, Pasadena, Calif.

• SPECIALTIES—Microwave plumbing and control systems.

• CONTRACTS—GSE components and subsystems.

• LITERATURE—Microwave Catalog and Handbook (No. **1088** on Card).

• CONTACT—W. E. Purdy, Marketing Director.

**DENISON ENGINEERING DIV., AMERICAN BRAKE SHOE CO.,** 1160 Dublin Rd., Columbus 16, Ohio

• SPECIALTIES—Checkout equipment and components; accumulators and simulator components for training and testing; launcher and erector components.

• CONTRACTS — Erector and launcher to raise Titan from ready storage position to launching position and attitude; hydraulic checkout stand for guidance system on Titan I, and II, Redstone, Mace, Hound Dog, and Polaris III. Test simulation components for Bomarc and Titan I and II.

• LITERATURE—GSE Bulletin (No. **1089** on Card).

• CONTACT—R. A. Manogue, Product Manager.

**DESIGNERS FOR INDUSTRY, INC.,** 4241 Fulton Parkway, Cleveland 9, Ohio

• SPECIALTIES—Computer holding fixtures; semiconductor test equipment with go/no-go readout.

• CONTRACTS—Missile checkout for large prime contractor; missile cable and harness checkout equipment for ABMA; computer holding fixture for Pershing.

• LITERATURE—Missiles and Aircraft Checkout Equipment Brochure (No. **1197** on Card); Missile Cable and Harness Tester Data Sheet (No. **1198** on Card); Tape Transport Data Sheet (No. **1090** on Card).

• CONTACT—J. F. Paryzek, Marketing Manager.

**HENRY G. DEITZ CO., INC.,** 12-16 Astoria Blvd., Long Island City 2, N.Y.

• SPECIALTIES — Safety interlock switches for liquid- or air-cooled electronic equipment. Pressure switches for inflated radardomes and air-supported structures.

• CONTRACTS—Subcontracts.

• LITERATURE — Switch Catalog (No. **1708** on Card).

• CONTACT—G. Dietz, RA 6-3347.

**DOUGLAS AIRCRAFT COMPANY, INC., MISSILES & SPACE SYSTEMS DIV.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

• SPECIALTIES—Standardized modular cabinetry for electronic, communications, testing, hydraulic, pneumatic equipment in full range of environmental conditions (heat, shock, radiation, etc.; standardized trailers for GSE subsystems and work areas; support system and subsystem design and manufacture for cryogenic, non-cryogenic and solid fuel rockets, missiles and space systems; field engineering and site operation for all classes of missiles and space systems GSE; cryogenic fuel static testing facilities for large space vehicles; liquid hydrogen RDT&E facilities for metals, plastics, components and subsystems.

• CONTRACTS—Propellant transfer, firing and launch equipment, checkout and testing equipment for Saturn S-IV; launching system and missile testing, monitoring, firing, checkout and calibration GSE; handling fixtures, hoists, dollies, vans, launchers, facilities for Nike-Zeus; handling, testing, checkout, shipping containers for Skybolt.

**DOW INDUSTRIAL SERVICE DIV., THE DOW CHEMICAL CO.,** 20575 Center Ridge Rd., Cleveland 16, Ohio.

• SPECIALTIES—Chemical and mechanical cleaning; pneumatic, hydraulic and leak testing of components and systems, chemical analyses.

• CONTRACTS—Chemical cleaning for Atlas, Titan I and II.

• LITERATURE—Supercleaning for Missiles (No. **1199** on Card); Chemical Cleaning for the Missile Industry (No. **1091** on Card).

• CONTACT—Dr. E. G. Fagersten, Mgr., Missile Task Force.

**M. DUCOMMUN CO.,** 580 Fifth Ave., New York 36, N.Y.

• SPECIALTIES — Precision stopwatches, split models and navigational chronographs, from 1/5 second to 1/100th of a second.

• CONTRACTS—0.001-second timers for Nike-Zeus, Boeing, Martin.

• LITERATURE—Minerva 261 Brochure (No. **1092** on Card).

• CONTACT—A. G. Stepchuk, Mgr.

**DUMONT ENGINEERING CO.,** 1356 Orizaba, Long Beach 4, Calif.

• SPECIALTIES — Hydraulic pneumatic swivel unions, elbows, tees; small in-line filters.

• CONTRACTS — Components Hawk missile loader and launcher.

• LITERATURE — Swivels Bull (No. **1200** on Card); Miniature Fil Bulletin (No. **1093** on Card).

• CONTACT — Roger Anderson Chief Eng., GE 3-4931.

**DYMEC DIV., HEWLETT-PACKA CO.,** 395 Page Mill Rd., Palo Alto, Ca

• SPECIALTIES—Digital data quisition and monitoring equipment; d tal data processng equipment to red information stored on computer tape IBM cards to analog X-Y plots graphs; high-speed automatic compon test equipment for 100% testing and spection of components such as tra istors, resistors, etc.; RF test syste such as doppler simulators and test s for calibration and maintenance of m rowave tranmitters and receivers.

• CONTRACTS—System that sim lates all Atlas telemetered signals; cou down timing and programming syst for Polaris; element of Titan check system.

• LITERATURE — Dymec Prod Catalog (No. **1201** on Card); Digital S tems Brochure (No. **1094** on Card).

• CONTACT—E. C. Morgan, Mgr., DA 6-1755.

**DYNATRONICS, INC.,** Box 2566, lando, Fla.

• SPECIALTIES — Automatic-tra ing telemetry antennas featuring pol ization diversity, frequency-delivers (10:1 b/w), and spurious-modulat suppression; universal PCM ground d stations featuring frame sync, varia word length, and computer data matting and editing; Timing systems generation of countdown signals synchronization and operation of ba tic tracking cameras; predetection reco ing systems (telemetry data collectio mobile van instrumentation; A-D/D converters, amplifiers, and other r-f s systems; range safety control and che out systems.

• CONTRACTS — Universal PC data station for Polaris, Minutem and Titan, single-sideband FM demu plexer for Saturn tests; broadband tenna feed for Atlantic Missile Ra to provide 100-1000 mc capability tracking and telemetry data recepti

• LITERATURE — Universal PC Data Station (No. **1202** on Card); vanced Predetection Data Collection S tem (No. **1203** on Card); Autom Tracking Telemetry Antenna System ( **1095** on Card).

• CONTACT—R. L. Parr, Mark ing Manager, TE 8-1100.

**DYNEX CO.,** 777 Dynex Dr., Pewaul Wis.

• SPECIALTIES—6000-psi hydra power systems from 1 to 100 HP vehicle drives, ground handling syste launchers and erectors.

• CONTRACTS — Hydraulics Nike trailer, hydraulics for 20 ton ro terrain crane for Corps of Engrs., draulics for universal engineer tra

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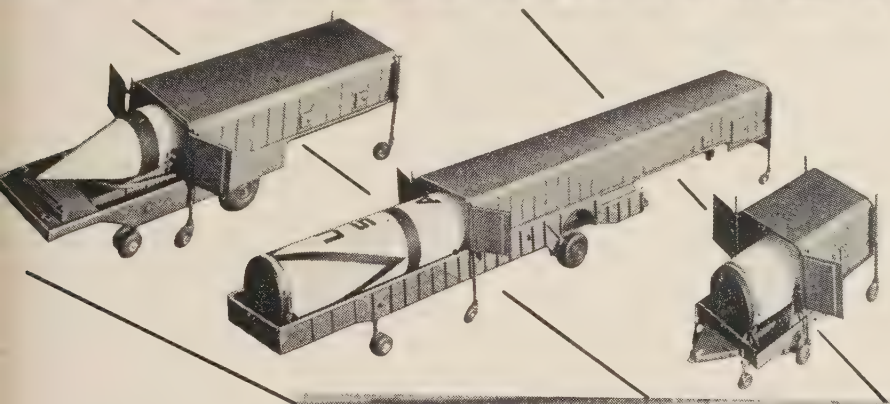

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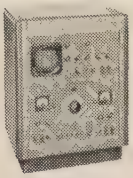

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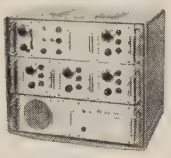

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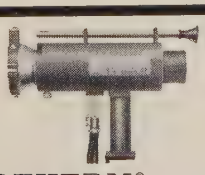

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• LITERATURE—Product Line Catalog (No. **1204** on Card); Paper on Hydrostatic Transmissions (No. **1205** on Card); High Pressure Hydraulics for Mobile Equipment (No. **1096** on Card).

• CONTACT—J. H. Groas, Sls. Mgr., System Engr. Div., DI 2-7253.

**EAGLE SIGNAL CO.,** 202 20th St., Moline, Ill.

• SPECIALTIES — Programers and pulse integrating timers for automatic checkout; hermetically sealed timers for launch monitoring and control; timers, motor driven switches and time delay relays for control circuitry, special timing devices built to customer specification.

• CONTRACTS—Timers to control Atlas and Titan silo operation, timers to control Minuteman launch functions, and timers to read Polaris count down.

• CONTACT—J. K. Larson, Control Engr., Ind. Div., 762-5571.

**ELECTRIC BOAT DIV., GENERAL DYNAMICS CORP.,** Groton, Conn.

• SPECIALTIES—Submarine missile launchers and checkout equipment; sophisticated launching and temperature control systems; electrical power distribution; capabilities for handlng nuclear power plants and radio-active materials; trainers; and vaneaxial fans for cooling electronic equipment.

• CONTRACTS—Drives and controls for Navy's 600-in. diameter radio telescope, integrated missile launching systems for Polaris submarine classes; training devices for Polaris submarine.

• LITERATURE—Custom Engineering and Design (No. **1206** on Card); Turbo-Slot Vaneaxial Fans for GSE (No. 1207 on Card); GSE Technical Publication Services (No. **1097** on Card).

• CONTACT—J. N. Spillane, Engineered Sales, Dept. 609, HI 5-4321 Ext. 1914, 1922.

**ELECTRIC MACHINERY MANUFACTURING CO.** 800 Central Ave., Minneapolis 13, Minn.

• SPECIALTIES — 400-cycle motor generator sets for aircraft and missile ground power.

• LITERATURE—The ABC's of 400 Cycle Generators (No. **1098** on Card).

• CONTACT—G. W. Sangster, Sr. Sales Specialist, FE 9-6751.

**ELECTROFLOR, INC.,** 7356 Santa Monica Blvd., Hollywood 46, Calif.

• SPECIALTIES—3-D display devices; electrically controllable color filters; arrays, matrices, transparent displays; flat-plate high resolution display.

• LITERATURE — Engineering Reports (No. **1099** on Card).

• CONTACT—J. R. Alburger, Pres., HO 7-1443.

**ELECTRONIC MEASUREMENTS CO. INC.,** Lewis St. & Maple Ave., Eatontown, N.J.

• SPECIALTIES — Production and distribution of current regulated DC power; voltage-regulated and constant-tube type and transistorized DC power supplies.

• LITERATURE — Semiconductor DC Power Supplies (No. **1208** on Card); DC Power Supplies (No. **1209** on Card); Electronic Measurements DC Main Systems (No. **1100** on Card).

• CONTACT—D. K. Stevens, Sls. Mgr., LI 2-0300.

**ELECTRONIX SYSTEMS DIV., TELE-COMPUTING CORP.,** 12838 Saticoy St., North Hollywood, Calif.

• SPECIALTIES—Automatic checkout systems.

• CONTRACTS — Automatic warhead testers for Nike-Ajax and Hercules. IFF test equipment for airborne coders for USAF and BuShips.

• CONTACT — Field Engineering Dept., corporate field offices.

**EMERSON ELECTRIC MANUFACTURING CO., ELECTRONICS & AVIONICS DIV.,** 8100 W. Florissant Ave., St. Louis 36, Mo.

• SPECIALTIES — Electronic, electrical, electromechanical, mechanical, hydraulic and pneumatic testing and calibrating equipment; manual or automatic test equipment with analog or digital evaluation circuitry for use at launch sites, A&T areas flight line, A&E shops, depot flight decks, O&R.

• CONTRACTS—Automatic tactical GSE for MD-7 fire control system on B-58; automatic tactical GSE for AN/-ASG-21 fire control system on B-52; field test set for Marine Corps AN/-KPQ-1.

• LITERATURE—Automatic Tactical Ground Support Equipment (No. **1101** on Card).

• CONTACT—J. Sheehan, Mgr., Support Equipment, CO 1-1800.

**EMERTRON, INC.** 14th & Coles Sts., Jersey City 2, N.J.

• SPECIALTIES—Line and shop level system test sets for checkout of radar altimeter equipment; SM radar, video mapping, fire control, early warning, shoran trainers, missile harness and umbilical connectors.

• CONTRACTS—AN/UPA 46 altitude reference simulator for A3J, AN/-APG-TIA fire control trainer for Air Force; missile harness and umbilical connectors for Atlas.

**ENGIS EQUIPMENT CO.,** 431 S. Dearborn St., Chicago 5, Ill.

• SPECIALTIES — Optical - electronic-mechanical tools, gages, and instruments; micro-alignment telescopes; theodolites; precision clinometers; autocollimators.

• LITERATURE—Company Catalog (No. **1500** on Card).

**EPSCO, INC.,** 275 Massachusetts Ave., Cambridge 39, Mass.

• SPECIALTIES—High speed, programmable analog-to-digital converters and signal conditioning modules for automatic checkout; PCM/video and signal conditioner checkout systems for pre-launch checkout of airborne PCM packages and airborne signal conditioner modules.

• CONTRACTS—Decimal digit, for ATLAS; programmable digital multimeter for AN/GJQ-9 Programming Set.

• LITERATURE—Programmable A to D Converters (No. **1209** on Card);

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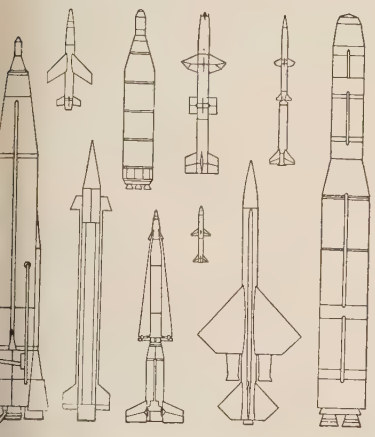

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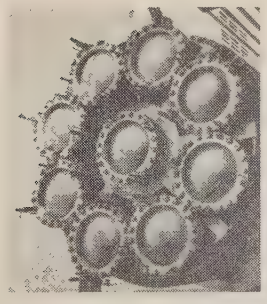

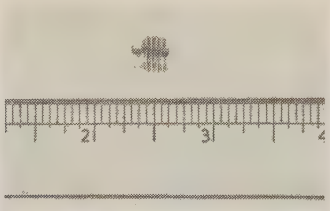

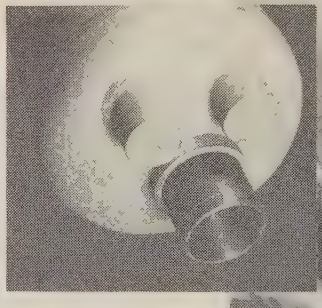

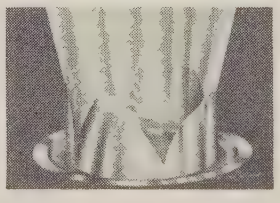

The safety head is a light-weight metal disc enclosed in a holding mechanism . . . a flange or suitable placement device. This thin metal membrane will fracture or rupture at a pre-determined pressure to provide an instantaneous and complete opening. Various metals and plastic coatings render it virtually immune to corrosive chemical action.

We invite you to submit your problems on functional or over-pressure control to our Engineering Department. We will assist you in selecting a safety head of suitable design for your service requirement. Contact your local BS&B office, or write to: Dept. 2-HB11, 7500 East 12th Street, Kansas City 26, Missouri.

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No. 225 on Reader Service Card

Solid-State Reversible Voltage to Digital Converter (No. **1210** on Card); Solid State Programmable Digital Multimeter (No. **1102** on Card).

• CONTACT—Joseph Bartholomew, Manager, Instruments Div., UN4-4950 Ext. 360.

**ERDCO ENGINEERING CORP.,** 136 Official Rd., Addison, Ill.

• SPECIALTIES — Automatic cable checkers, circuit test systems, mechanical test systems, pneumatic and hydraulic test systems.

• CONTRACTS — Combustible gas alarms and toxic gas indicators for SAC B-52, KC-135, and C-130 aircraft.

• CONTACT — J. S. Bogen, Pres., KIngswood 3-6733.

**ERIE-PACIFIC DIV., ERIE RESISTOR CORP.,** 12932 S. Weber Way, Hawthorne, Calif.

• SPECIALTIES — Electronic counters and timers.

• CONTRACTS — 1-mc programmable counter for Polaris; period meter for F-104.

• LITERATURE—Miniature Digital Interval Timer Data (No. **1211** on Card); Period Meter Specs (No. **1212** on Card); 20 MC Universal Timer Counter Specs (No. **1103** on Card).

• CONTACT—E. C. Titcomb, Sales Mgr., OR 8-5418, OS 5-4752.

**FAIRCHILD CAMERA & INSTRUMENT CORP., DEFENSE PRODUCTS DIV.,** 300 Robbins Lane, Syosset, N. Y.

• SPECIALTIES — Data reductions, reproduction, storage, retrieval and display systems; instrumentation and control systems; simulation and training devices; checkout equipment; adjustable planetary test and turn/tilt stands.

• CONTRACTS — Tri-service photo transmission system for unmanned vehicles; variable magnification projection viewers for Air Force; automatic exposure control system for White Sands Proving Grounds cinetheodolite.

• LITERATURE—Facilities & Capabilities Brochure (No. **1213** on Card); Photo Transmssion System Brochure (No. **1214** on Card); Automatic Exposure Control Data Bulletin (No. **1104** on Card).

• CONTACT—J. Throckmorton, Sls. Mgr., Display & Support Equipment, PR 3-2000 Ext. 373.

**FAIRCHILD CONTROLS CORP.,** 225 Park Avenue, Hicksville, N. Y.

• SPECIALTIES — Precision single turn multi-turn and wirewound potentiometers, precision conductive plastic potentiometers, potentiometric pressure transducers, silicon semi-conductor strain-gage pressure transducers, solid state zero drift d-c amplifier, rate gyros, accelerometer.

• CONTRACTS — Pershing, Atlas, and Polaris.

• LITERATURE—Single-Turn Wirewound Precision Potentiometers Brochure (No. **1215** on Card); Silicon Semiconductor Strain Gage Pressure Transducer Brochure (No. **1216** on Card); Rate Gyro and Accelerometer Brochure (No. **1105** on Card).

• CONTACT — T. F. D'Andrade, Natl. Sales Mgr., WE 8-5600 Ext. 104.

**FALSTROM CO.,** 71 Falstrom Court, Passaic, N. J.

• SPECIALTIES—Design and fabrication of metals consoles, cabinets, racks, and test benches.

• CONTRACTS — Shielded console for Minuteman, computer enclosure for Nike-Zeus, GE launch for Polaris.

• LITERATURE—Consoles & cabinets (No. **1217** on Card); Standard Rack Cabinet Bulletin (No. **1218** on Card); Standard Console Bulletin (No. **1106** on Card).

• CONTACT—R. E. Hill, Sls. Mgr., PR 7-0013.

**J. W. FECKER DIV., AMERICAN OPTICAL CO.,** 6592 Hamilton Ave., Pittsburgh 6, Pa.

• SPECIALTIES—Automatic checkout equipment for gyros and navigation systems; motion simulation and star simulation equipment; precise optical, electronic and mechanical alignment equipment.

• CONTRACT—Automatic checkout of control gyro package for Atlas; automatic checkout of astro inertial guidance system for Skybolt; test equipment for control gyros on Thor-Delta.

• LITERATURE — Multimode Test Table (No. **1219** on Card); Multirange Rate Table (No. **1220** on Card); Sidereal Rate Table (No. **1107** on Card).

• CONTACT—James Colker, Chief Engineer, EM 1-7617 Ext. 48.

**FEDERAL ELECTRIC CORP.,** 621-671 Industrial Ave., Paramus, N. J.

• SPECIALTIES — Operation and maintenance of instrumentation and communication facilities for land bases and tracking and recovery ships; installation maintenance, operation of instrumentation and tracking radar, telemetry, optical devices, drone tracking and control systems, data transmission equipment and countdown systems.

• CONTRACTS — Activation Titan Missile Base T-4, Pacific Missile Range, Eglin Gulf Test Range.

• LITERATURE — Missile/Space Vehicle Site Activation (No. **1108** on Card).

• CONTACT — R. A. Marshall, CO 1-7200 Ext. 427.

**FENWAL INC.,** Pleasand St., Ashland, Mass.

• SPECIALTIES—Temperature control units for detection, indication and control explosion protection systems to detect and suppress explosion.

• CONTRACTS—Is Explosion Prevention Enough (No. **1221** on Card); Condensed Catalog (No. **1222** on Card); Engine Fire and Overheat Detection (No. **1109** on Card).

• CONTACT—K. S. Brock, Manager, Market Development, TR 5-6111.

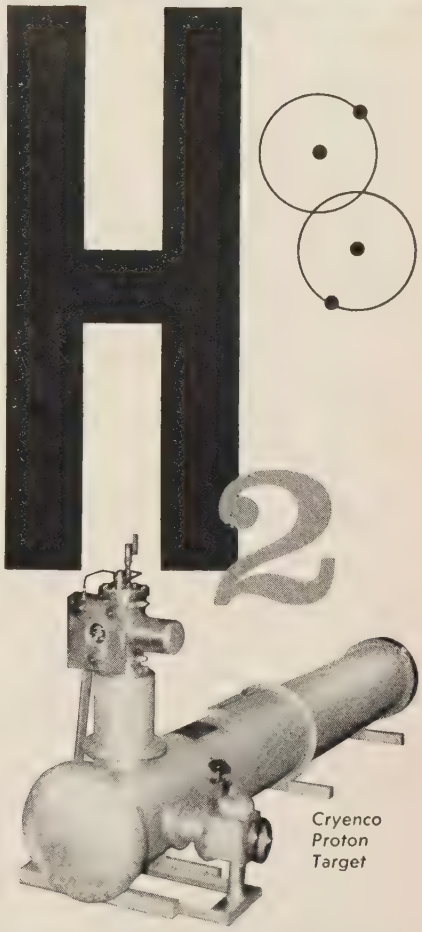
**FLEXIBLE METAL HOSE MANUFACTURING CO.** 777 W. 16th St., Costa Mesa, Calif.

• SPECIALTIES — Flexible metal hose for all types of media, insulated assemblies for transfer of liquid oxygen and nitrogen; stainless steel bellows and ducts, high and low temperature electrical conduit assemblies.

• CONTRACTS—Hose and duct assemblies for Atlas and test trailer; hose assemblies for Titan II.

• LITERATURE—Hose Engineering


**CRYOGENICS**




Cryenco Proton Target

Write us for low temperature, high vacuum equipment to use in your liquid hydrogen work!

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- **Hydrogen Cryostats**
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- **Liquid Storage and Transport**
- **Refrigerators 20°-30° K**

Liquid hydrogen provides an ideal medium for research in the range of 20°-30° K. Cryenco engineers have pioneered many of the phases of work in this area. Today, these men are available to you for production of equipment and hardware that you need—both standardized and custom built. An example of the background of these men is the fact that Cryenco engineers have worked on all of the major refrigerator-liquefiers used for hydrogen bubble chambers in the free world. A 2,570 watt, 208 liters/hour hydrogen refrigerator-liquefier is now under construction in our plant. Hydrogen dewars and cryostats are being designed and fabricated from small sizes up to railroad tank car capacities. Cryenco men are ready to go to work on your hydrogen equipment problems—free your physicists and engineers for fundamental work. Write for standard equipment catalog, or send us your specific requirements for our quotation.

**CRYENCO**

**Cryogenic Engineering Co.**
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Low Temperature, High Vacuum Equipment and Engineering

No. 226 on Reader Service Card

and Data Prints (No. **1223** on Card)· Bellows Engineering Chart (No. **1110** on Card).

• CONTACT—Elton Hallett, Pres. MI 6-4851.

**FLEXONICS DIV. CALUMET & HELCA, INC.,** 420 E. Devon Ave., Bartlett, Ill.

• SPECIALTIES—Flexible and rigid metal tubing and hose, expansion joints, compensators and other pipe motion and temperature or pressure control elements.

• CONTRACTS — Medium-pressure flexible servicing hose for semi-trailer tank A/M 32R-6; flexible metal hose assembly used for Brookley AFB compressed gas cyl. oxygen servicing trailer, high pressure servicing hose for semi-trailer

• LITERATURE—Metal Hose Report (No. **1224** on Card); Expansion Joints (No. **1225** on Card); Stainless Steel Tubing (No. **1226** on Card).

• CONTACT—R. F. Edgar, Product Sales Manager, TE 7-1811.

**FLIGHT SUPPORT DIV. PACIFIC AIRMOTIVE CORP.,** 11248 Playa St., Culver City, California

• SPECIALTIES—Hydraulic, pneumatic, electronic and mechanical test stands for rotating and non-rotating units.

• CONTRACTS—Portable 100 micron vacuum pump for Atlas, magneto test stand for Army; portable pressure tester for Navy.

• LITERATURE—Company Brochure (No. **1227** on Card), New Product Information (No. **1228** on Card).

• CONTACT—H. R. Kelly, Division Sales & Contracts Manager, EX 1-7161.

**FLUID DYNAMICS INC.,** 90 West St., New York, N.Y.

• SPECIALTIES — Filters for high pressure gas and liquid systems, cryogenic systems and high temperature system.

• CONTRACTS—Filters for Titan II UDMH-hydrazine handling, Titan I cold helium system, Atlas pressurization system.

• LITERATURE — High-Pressure T-Type Filters (No. **1704** on Card). High-Flow Y-Type Filters (No. **1800** on Card).

• CONTACT—W. J. Spencer, Sales Mgr., BA 7-9229.

**FMC CORP., ORDNANCE DIV.,** Box 367, San Jose 3, Calif.

• SPECIALTIES—Armored and unarmored military tracked and wheeled vehicles, hydrofoil vehicles, amphibious landing vehicles, nuclear handling equipment, remote control systems, propellant handling systems, and missile support systems and equipment.

• CONTRACTS—Launcher - erector and hydraulic skid for Bomarc, pod assembly and auxiliary power unit for Mauler, tracked vehicles for Pershing and Mauler systems.

• CONTACT—J. J. MacRostie, Manager, Preliminary Design Engineering Dept. CY 4-8124.

**S. G. FRANTZ CO., INC.,** Box 1138, Trenton 6, N.J.

• SPECIALTIES—High pressure magnetic separators for removing ferrous grit from missile and aircraft test stand and ground supply hydraulic systems at working pressures up to 5000 psi.

• LITERATURE—Magnetic Separators Bulletin (No. **1229** on Card.)

**FRONTIER ELECTRONICS CO.,** 4600 Memphis Ave., Cleveland 9, Ohio.

• SPECIALTIES — Countdown clocks, digital clocks and range timing for data correlation and control; digital modules miniaturized for high density control systems; precision frequency references, programmers and telemetry transmitters for trajectory information.

• CONTRACTS — Frequency control and cable testers for Saturn, frequency reference for Hound Dog

• LITERATURE—Advanced Art in Products and Technology (No. **1230** on Card).

• CONTACT—P. E. Lannan, Vice President, SH 9-0700.

**FRUEHAUF TRAILER CO., MILITARY PRODUCTS DIV.,** 5137 S. Boyle, Vernon, Calif.

• SPECIALTIES — Highway, rail, ocean and air and physical and environmental protection for missile components, ground support electronics and personnel; transport and storage vehicles; mobile transporters, launchers and booster dollies; VTOL launchers; electronic checkout and maintenance vans; electronic shelters.

• CONTRACTS — Family of vehicles for Nike, Hawk, Sergeant.

• LITERATURE—Military and Missile (No. **1231** on Card). Mobile Paragon Shelter (No. **1232** on Card).

• CONTACT—John Gustke, Chief Sales Engineer, WA 1-2410.

**GENERAL COMMUNICATION CO.,** 677 Beacon St., Boston 15, Mass.

• SPECIALTIES — Radar test sets, radar beacon simulators, peak pulse power calibration equipment, transponders, general purpose laboratory power supplies for operating and testing radar beacons, microwave test equipment, and components, coaxial switches, specialized instrumentation and sub-systems, measurement standards.

• CONTRACTS — L - band pulse power calibrator for calibration of BuShips IFF/TACAN equipment; BDS Radar Test Set for testing Air Force radar and beacon equipments in the 8500-9500 mc frequency range; FAA navigation equipment for transmitting and monitoring a standard test signal for VOR omni-range receiver calibration.

• LITERATURE—Product Catalog (No. **1809** on Card). Facilities Brochure (No. **1233** on Card).

• CONTACT—J. R. Richmond, Assistant Sales Mgr., CO 7-6030.

**GENERAL DYNAMIC/ELECTRONICS,** 1400 N. Goodman St., Rochester 3, N.Y.

• SPECIALTIES—Punched-tape programmed automatic test equipment with solid-state digital logic; special purpose RF and microwave generators; Special pulse generators and analyzers; Trsiners and Simulators for reconnaisance, countermeasures, and digital data processing systems; special purpose solid state digital computers; Timing systems with real time and command signals; single sideband and ASW ground support.

• CONTRACTS—Semi-automatic test equipment (Safe) for Atlas; flight line and maintenance signal generators to checkout Navy Sonobouy Receivers, RF test set for Nike-Zeus.

• LITERATURE—Scate Checkout Brochure (No. **1234** on Card); Programmable Generator Data Sheets (No. **1235** on Card); Dat Sheets on Test and Checkout (No. **1236** on Card).

• CONTACT—Z. Benim, Asst. Chief Engr., FI 2-8000 Ext. 2255.

**GENERAL DYNAMICS/FT. WORTH DIV.,** Box 748, Fort Worth, Texas.

• SPECIALTIES—Ground handling equipment, work stands, slings, and handling fixtures; mobile equipment for transporting, lifting, and positioning aircraft components and ordnance stores; ground powered equipment including high pressure, high capacity ground air conditioning units; hydraulic equipment including high pressure, high temperature pumping units, fluid servicing, filtration and decontamination units; electronic checkout equipment; advanced support maintenance concepts; devices include simulators, trainers, operational panels, suitcase trainers; experience with airborne nuclear reactors and related support.

• CONTRACTS—Family of support equipment for B-58 including electrical, electronic, mechanical, hydraulic and ground handling devices; procedures and adapters for Atlas; experimental equipment for operaton in nuclear environments for USAF and Army.

• LITERATURE—Aerospace Ground Equipment (No. **1237** on Card); Training Devices Brochure (No. **1238** on Card); Tooling Capabilities Brochure (No. **1239** on Card).

• CONTACT—E. E. Hile, Chief Des Eng., PE 8-7311 Ext. 2302.

**GENERAL DYNAMICS/POMONA** Pomona, Calif.

• SPECIALTIES — Automatic test equipment for factory checkout; developmental testing and electronic, hydraulic, pneumatic and mechanical handling equipments.

• CONTRACTS — Radar Performance Monitor, Checkout Equipment for Atlas Guidance System, Checkout Equipment for Terrier-Tartar.

• LITERATURE — Radar Performance Monitor (No. **1240** on Card); Aero Surface Analyzer (No. **1241** on Card); Rocket Motor Temperature Analyzer (No. **1242** on Card).

• CONTACT—L. J. Wetzler, supr.

**GENERAL ELECTRIC CO., COMMUNICATION PRODUCTS DEPT.** Lynchburg, Va.

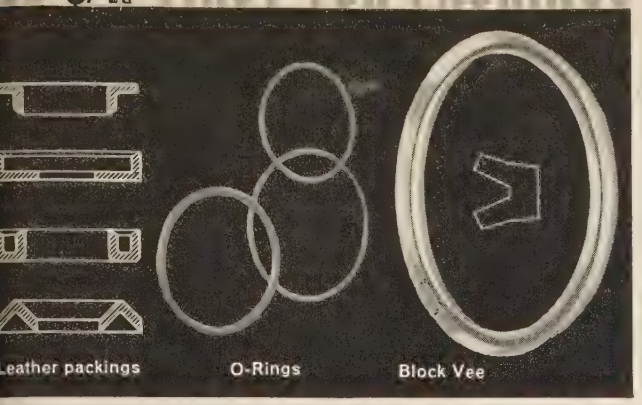
• SPECIALTIES — Microwave communications for test range data link low cost tropospheric scatter systems for transmitting teletype and data information at hardened missile sites; base communications.

• CONTRACTS—Base Communications for Mercury; car and truck radio for missile construction sites; microwave communications for Atlantic test range.

• LITERATURE — Two-Way Radio Catalog (No. **1243** on Card); Microwave Communications (No. **1244** on Card); Thin Route Tropo Brochure (No. **1245** on Card).

**GENERAL ELECTRIC CO., LIGHT**

## EE C/R FIRST-FOR PACKINGS




### Meet extreme conditions, deliver long service life

R Sirvis Leather U, Vee, Cup and nge packings can seal depend- ly up to 10,000 psi; others will stay xible at —100°F.; specials for use —300°F. Stable in oil, water, sol- nts such as toluol and trichlor- nylene. Request Size List LMC-1.

R Block Vee packings seal better, st less, are easily assembled on draulic, pneumatic pistons or ds. More compact, perform effi- ciently at higher psi than U pack- ings. Molded of a wide range of temperature and chemically resist- ant elastomers. Request Catalog No. BV-60.

C/R O-Rings are available conform- ing to many MIL AMS, SAE-ASTM specifications. Silicone rubbers and other compounds are available for critical or unusual conditions. Write for Bulletin OR-57.

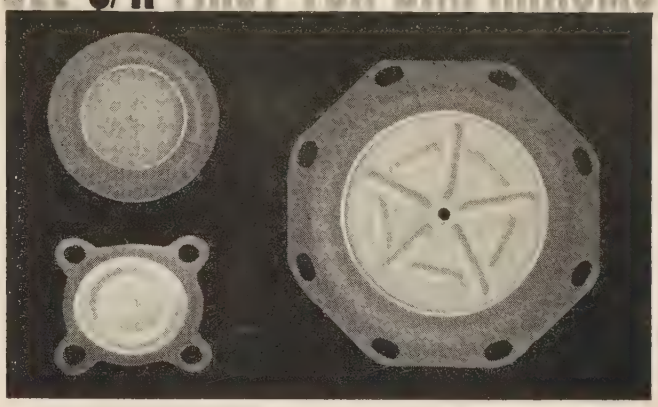
**CHICAGO RAWHIDE MANUFACTURING CO.**

1293 Elston Avenue • Chicago 22, Illinois

In Canada: Chicago Rawhide Mfg. Co. Ltd., Brantford, Ont.

Export Sales: Geon International Corp., Great Neck, New York

## SEE C/R FIRST-FOR DIAPHRAGMS



### To handle basic or advanced fuels, lubes, gases in normal or extreme applications

Whether simple or critical tolerances, exact concentricities, or flawless bonding are needed, C/R elastomer engineers can deliver the high dependability diaphragms you require. They are experts in compounding and molding special materials such as Viton-A*, Silastic LS-53, Teflon*, as well as butyl and the common synthetic rubbers.

They have an unusual level of experience in producing diaphragms for critical applications with high or low temperatures involving difficult mediums to be sealed. This experience and our unique facilities are at your service. Write for Bulletin SD-100 or call your nearest C/R salesman.

**DuPont Reg. T.M.*

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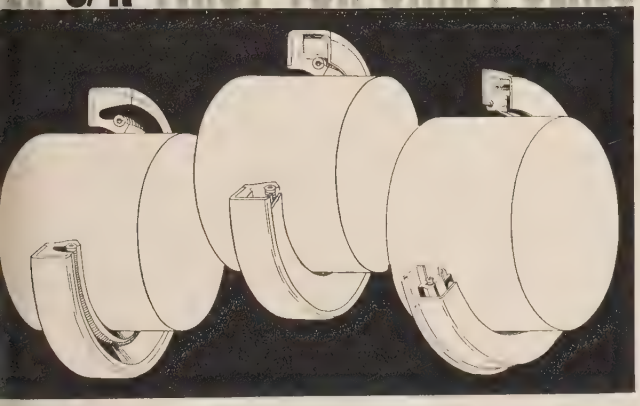
## EE C/R FIRST-FOR SHAFT SEALS



### housands of sizes — ost from stock

ver 20 types, 7,500 sizes for shafts om ¼" to 50" O.D. for applications om simple grease retention and rt exclusion—to retention of wide nge of oils, solvents, gases, emicals on hot, high-speed shafts here seal dependability is a must. nmatched engineering service to lp you.

*Write direct or call your nearest C/R salesman.*

### For lower costs on large runs — C/R Scotseals®

You can reduce costs with C/R Scotseals wherever high production runs, difficult oil retention, or where equipment downtime and replacement costs are critical. The C/R Scotseal seals on its integral sealing surface—not on the shaft or bore. Write for Bulletin SS-100.

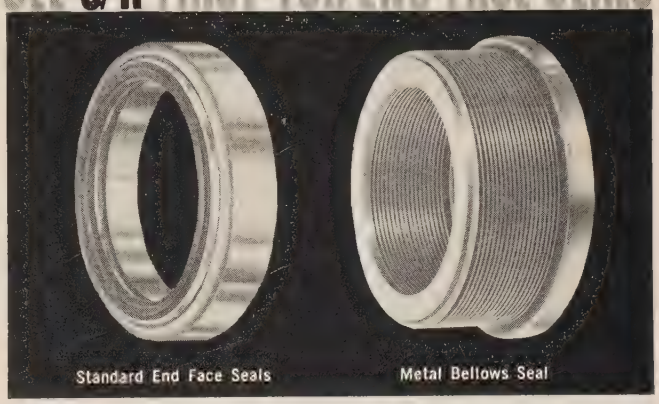
**CHICAGO RAWHIDE MANUFACTURING CO.**

Oil Seal Division: 1293 Elston Avenue, Chicago 22, Ill.

*In Canada: Chicago Rawhide Mfg. Co. of Canada Ltd., Brantford, Ont.*

*Export Sales: Geon International Corp., Great Neck, New York*

## SEE C/R FIRST-FOR END FACE SEALS




### Standard face seals deliver maximum efficiency in minimum space

Standard sizes for ¾" to 4" shafts. Pressures to 500 psi; temperatures to 500°F; peripheral speeds to 15,000 fpm. sealing external or internal pressures. Two complete series, long or short—pre-engineered to meet the widest possible range of sealing requirement. Standard mating rings also available. Write for Bulletin EF-100.

### For Hyper-Critical Conditions — C/R Metal Bellows Seal

For temperatures from — 400° to 1000°F., pressures to 500 psi, shaft speeds to 80,000 rpm *plus*, consider the C/R Metal Bellows Seal. Proved in use on rocket and missile compressor power units, turbine starters, fuel pumps sealing cryogenic high energy fuels, radioactive, etc. Write for Bulletin MBS-1, or call your nearest C/R salesman.

**CHICAGO RAWHIDE MANUFACTURING CO.**

Oil Seal Division: 1293 Elston Avenue, Chicago 22, Ill.

*In Canada: Chicago Rawhide Mfg. Co. of Canada Ltd., Brantford, Ont*

*Export Sales: Geon International Corp., Great Neck, New York*

No. 227 on Reader Service Card

**MILITARY ELECTRONICS DEPT.,** French Rd., Utica, N. Y.

• SPECIALTIES — Automatic and manual checkout equipment for air and spaceborne guidance and communication equipment, radar, computers, countermeasure receivers and transmitters trainers and test simulators; toxic and explosive vapor detection equipment.

• CONTRACTS — Countermeasure equipment test sets, operational monitors, antenna couplers, wave guides and meters, pwb repair kits, servo noise amplifier test sets, coaxial test assemblies, tuner test sets, noise response test sets, power meters for B-52; toxic vapor detectors for Atlantic Missile Range.

• LITERATURE—Special Test and Support Equipment for Electronic Countermeasure Systems (No. **1246** on Card); New General Electric Vapor Detector (No. **1247** on Card).

• CONTACT—F. H. Jones, Prod. Info., SW 7-1000 Ext. 8508.

**GENERAL ELECTRIC CO., LIGHT MILITARY ELECTRONICS DEPT., ARMAMENT & CONTROL SECTION,** 600 Main St., Johnson City, N. Y.

• SPECIALTIES — Programer-comparators and adapter drawers for automatic checkout systems; flight line, base and depot test equipment; test benches for flight control systems; checkout of gyros and accelerometers; system testers for fire control systems; fixtures for optical sight checkout and alignment; special test equipment for radar systems; analog and digital testers.

• CONTRACTS—Republic Aviation/Air Force; automatic and manual checkout equipment for F105D; Fire Control and Flight Control Systems; adapter drawers for automatic checkout of AN/APS-96 Radar on W2F-1; programer comparator for test system for automatic checkout of 412L system circuit boards.

• LITERATURE — GEPAC "100" Automated Support Equipment (No. **1248** on Card); How General Electric Provides Full Spectrum Support (No. **1249** on Card); GEPAC "200" Programer-Comparator (No. **1250** on Card).

• CONTACT — H. S. Livingston, Mgr., Support Equip. Sales.

**GENERAL ELECTRIC CO., ORDNANCE DEPT.,** 100 Plastics Ave., Pittsfield, Mass.

• SPECIALTIES—Missile launching and handling equipment; missile checkout, monitoring, firing equipment; manipulation equipment.

• CONTRACTS — Launching and handling system for Mk 12 Talos; fire control system for Mk 80 Polaris; optical alignment system for Navy 600-ft radio telescope.

• LITERATURE—Ordnance Department Brochure (No. **1251** on Card); Mk 12 system (No. **1252** on Card); Atlas Tracker (No. **1253** on Card).

• CONTACT—R. C. Sharp, Mgr., Prod. Info., HI 3-3561 Ext. 3013.

**GENERAL MILLS, INC., ELECTRONICS GROUP,** 1620 Central Ave., Minneapolis 13, Minn.

• SPECIALTIES—Automatic checkout of airborne electronic systems; automatic handling equipment including means for remote handling of radioactive toxic or explosive materials, rocket engines, and rocket fuels; digital computer systems for data reduction and remote control of missiles and drones.

• CONTRACTS—Radar system tester for B-47, B-52 etc; remote handling system for experimental rocket motors and fuels for Dow Chemical Co.; digital computers for drone control.

• LITERATURE — Radar System Tester AN/GPM-1/25 (No. **1254** on Card); Automatic Handling Equipment (No. **1255** on Card); Digital Computer System (No. **1256** on Card).

• CONTACT—H. E. Taylor, Jr., Dir. of Mktg., ST 9-8811 Ext. 267.

**GENISCO INC.,** 2233 Federal Ave., Los Angeles 64, Calif.

• SPECIALTIES — High precision centrifuges and rate of turn tables for "G" load enviromental testing; instrumentation accelerometers analog to pulse duration instrumentation; a 52 ft. diameter centrifuge in design study that will extend the state of the art three fold.

• CONTRACTS—Transport monitor for shock recording Minuteman in transit rate of turn tables for enviromental testing for NATO.

• LITERATURE—Analog to Pulse Duration Instrumentation (No. **1257** on Card); 1200 Series "G" Accelerators (No. **1258** on Card); Accelerometers (No. **1259** on Card).

**GIANNINI CONTROLS CORP.,** 1600 S. Mountain Ave., Duarte, Calif.

• SPECIALTIES — Automatically programed test equipment for air data components and systems and for servo mechanisms; analog and digital instrumentation for monitoring electrical, physical, and mechanical parameters; instrumentation involving radioisotopes.

• CONTRACTS — Analog "go/no-go" voltage comparator for Trace automatic test equipment for Polaris; automatically programed precision pressure generator for W2F/A2F Central Air Data Computer checkout; jetevator servo position indicator (instrument servo with digital output) for Polaris.

• LITERATURE—Portable Pressure Generator Notes (No. **1260** on Card); Dynamic Servo Analyzer (No. **1261** on Card); Servo Ratiometer Bulletin (No. **1262** on Card).

• CONTACT—S. H. Levin, Systems Sales Mgr.

**B. F. GOODRICH AERO SPACE & DEFENSE PRODUCTS** 500 S. Main St. Akron, Ohio.

• SPECIALTIES—Lightweight high-load capacity pneumatic and solid tire wheels and casters; air and hydraulic actuated drum, disk brakes and brake control systems for vehicles and launcher-erector mechanisms; liquid-cooled disk brakes for prolonged energy absorption applications; metal seals for rod, piston, and rotary applications handling cryogenic, fuel, hydraulic, pneumatic, and exotic fluid systems operating to 37,000 psi and 1000 deg F.

• CONTRACTS—Lightweight wheels for Pershing launcher erector; springs applied and hydraulically released brakes to stop and hold Atlas and Titan missile elevators in event of hydraulic failure. Metallic seals to Republic Aircraft Allison, Boeing, TWA, High Volta Engineering for extremely high and lo temperatures.

• LITERATURE—Aircraft Whee and Brakes (No. **1263** on Card); Di Brakes (No. **1264** on Card); Metall Seals (No. **1265** on Card).

• CONTACT—R. T. Rabe, Pro Mgr., Troy, Ohio, 332-5610.

**GOODYEAR AIRCRAFT CORP.,** 12 Massillon Rd., Akron 15, Ohio.

• SPECIALTIES—Mobile air tran portable units; over the road transporte erectors; automatic electronic grou and preflight testers; operational flig trainers and tactics trainers.

• CONTRACTS—Missile transport erector for Atlas: booster shipping co tainer for Polaris; complete GSE syste for Mace.

• LITERATURE—Central Prograr mer and Evaluator Flyer (No. **1266** Card); Electronics Test and Checko Equipment Brochure (No. **1267** on Card Air-Spring Suspension System Flyer (N **1268** on Card).

• CONTACT — W. L. Goddar Litchfield Park, Ariz., WE 5-9331.

**THE GORMAN-RUPP CO.,** 305 Bo man St., Mansfield, Ohio.

• SPECIALTIES—Self-priming ce trifugal pumps for missile and aircra fueling; fuel transfer and bulk fuel ha dling in portable and permanent fu systems; pumps powered by all types prime movers including gas turbines.

• CONTRACTS — Aircraft refuel pump on Air Force tank truck; fuel di pensing and transfer pump for Mari Corps and Army.

• LITERATURE—Gorman-Rupp I troduction Brochure (No. **1269** on Car

• CONTACT—R. E. Owens, Mg Govt. Sales, LA 4-4211.

**GPL DIV., GENERAL PRECISIO INC.,** 63 Bedford Rd., Pleasantvil N.Y.

• SPECIALTIES—For in-flight a flight-line testing Doppler-Inertial Na gation systems.

• CONTRACTS — System test for Dopler Inertial Navigation syste to be used in ALRI program.

• LITERATURE—ALRI Test Equ ment News Release (No. **1270** on Car

• CONTACT—Stan Hayes, As Mgr., RO 9-5000.

**GREAT LAKES STEEL CORP.,** Ecor Detroit 29, Mich.

• SPECIALTIES — High - streng steels for ground structures, erectors a launchers, trailers.

• CONTRACTS—Steel for Sergea launcher and Nike-Hercules trailer.

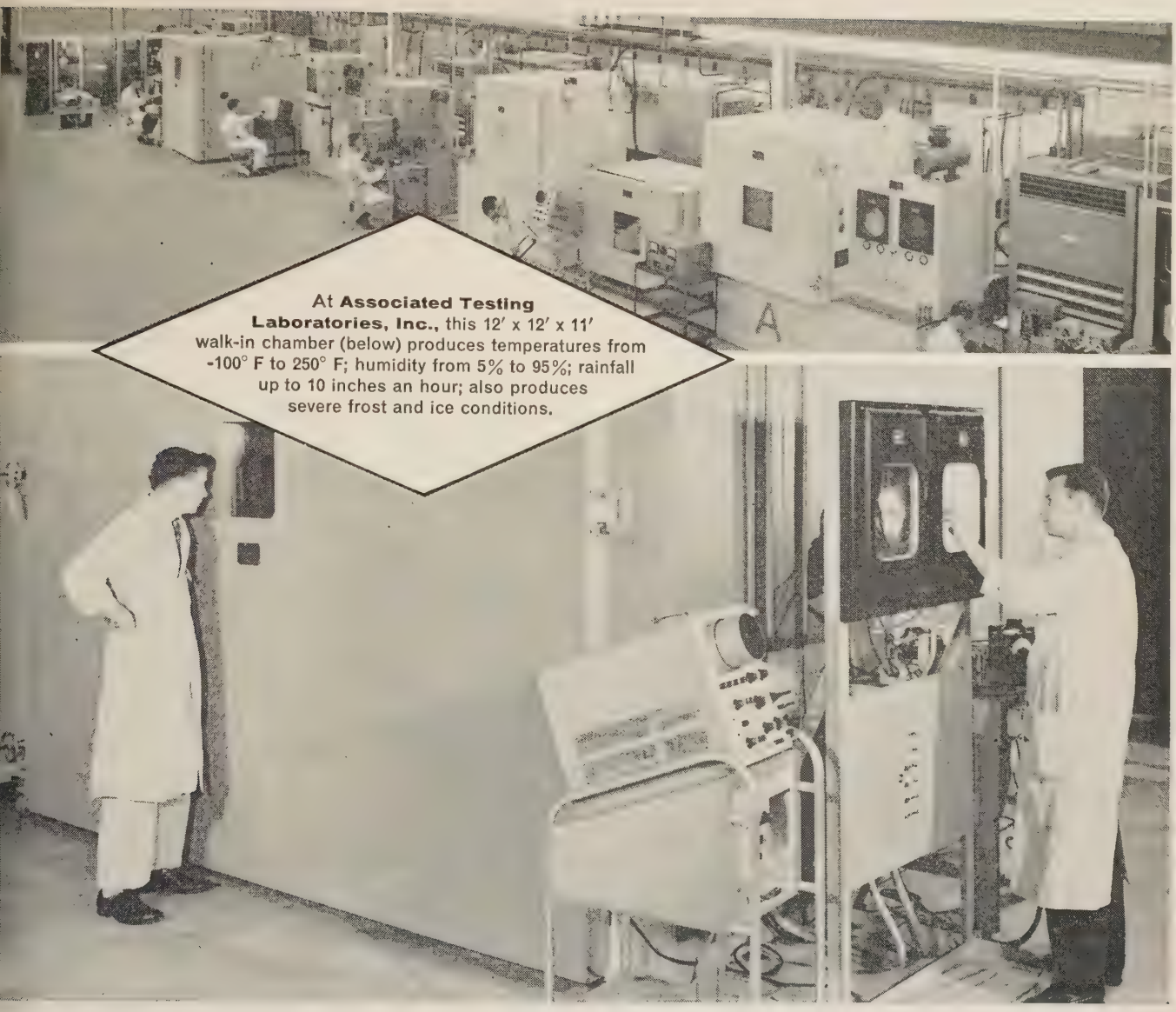
• LITERATURE—NAXTRA St (No. **1274** on Card); NAX High Tens Steel (No. **1275** on Card); GLX Ste (No. **1276** on Card).

**GREER HYDRAULICS, INC.,** 5930 Jefferson Blvd., Los Angeles 16, Calif

• SPECIALTIES—Components a complete hydraulic power packages.

• CONTRACTS—Titan I, Titan and Atlas.

• LITERATURE—Product Bulle (No. **1271** on Card); Guide to Hyd Pneumatic Accumulators (No. **1272** Card).



At **Associated Testing Laboratories, Inc.**, this 12′ x 12′ x 11′ walk-in chamber (below) produces temperatures from -100° F to 250° F; humidity from 5% to 95%; rainfall up to 10 inches an hour; also produces severe frost and ice conditions.

# Problem: **SIMULATE SPACE TEMPERATURES**
# Solution: **LIQUID CARBONIC DOES IT WITH LIQUIFLOW***

Simulating space conditions quickly and accurately is the job of Associated Testing Laboratories, Inc., Wayne, New Jersey. Humidity, altitude, temperature, vibration, shock, sand, dust—whatever your test specifications, Associated is equipped for the job.

Since liquid $CO_2$ provides the required refrigeration for Associated's chambers, the company keeps permanent Liquiflow* storage vessels at their Wayne, N.J.; Winter Park, Fla.; and Burlington, Mass. sites. *Mechanical* refrigeration units of comparable capacity would require enormous capital investments.

Associated Testing Laboratories also realizes these advantages with Liquiflow*: rapid temperature pulldown; reduction of engineering man-hours and manual labor; elimination of breakdown worries and maintenance.

When you need an economical refrigerant and a more flexible operation—plus an always reliable supply of $CO_2$—call your Liquid Carbonic representative. There are more than 135 Liquid Carbonic distributing points throughout the country.

**Liquiflow is Liquid Carbonic's registered trade-mark for liquid carbon dioxide systems.*

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DIVISION OF **GENERAL DYNAMICS**

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No. 228 on Reader Service Card

Minuteman Transporter-Erector. Prime Contractor—Boeing Airplane Company, Seattle Wash. Missile Container—Military Div. of Cessna Aircraft Co., Wichi Kansas. Tractor & Trailer—GMC Truck & Coach Div., Pontiac, Mich.

# MAGNESIUM LIGHTENS MINUTEMAN CARRIER...

## helps keep it rigid

This huge transporter-erector will carry a Minutem missile to its launching site, then raise it vertical ready for placement in the underground launchi silo. Magnesium was selected for many critical par because of its stiffness and light weight . . . about 22 pounds of sheet, plate and extrusions. This is 4 pounds *less* than the weight of the material original considered.

The container must be light to meet highway lo limits and rigid to protect the missile. For the reasons, all side panels, rear doors and access doo are made from magnesium AZ31B alloy sheet.

In the tractor unit, magnesium sheet and extr sions form the framework, panels, roof and floo *Even the bumper* is of strong, lightweight magnesiu alloy. Wherever a combination of light weight a stiffness is needed . . . for vehicle bodies, containe housings, aircraft and missile structures . . . there' Dow magnesium alloy to do the job. For informatio write THE DOW METAL PRODUCTS COMPANY, Midlan Michigan, Merchandising Dept. 1113EW11.

DOW MAGNESIUM MILL PRODUCTS

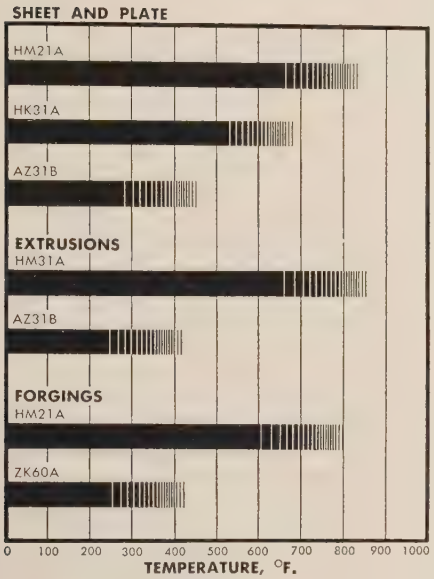
**THE DOW METAL PRODUCTS COMPAN**

*Division of The Dow Chemical Compa*

DOW

Magnesium alloys for missiles and aircraft...

**HIGH STRENGTH UP TO 800°F.!**




How thorium has extended magnesium's useful service temperature range.

High service temperature range and light weight . . . designers of missiles and aircraft can count on both with Dow magnesium-thorium alloys for elevated temperature use. This family of alloys offers strength and resistance to creep at high temperatures. Magnesium-thorium alloys are used in the Polaris, Titan, Talos and Bomarc missiles; in Agena and Scout vehicles; and in the F-105 aircraft.

Forgings of Dow alloy HM21A have excellent mechanical properties up to 800°F. Other alloys for extrusions, and sheet and plate, are available for use in the 300°— 800°F. range, for body skins, ducts, cowlings, electronic equipment housings, wings, fins and other applications.

Dow elevated temperature magnesium-thorium alloys are easily welded, without requiring stress relief. For detailed information and data, write THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Dept. 1155EW11.

DOW MAGNESIUM MILL PRODUCTS

**THE DOW METAL PRODUCTS COMPANY**

*Division of The Dow Chemical Company*

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• CONTACT—Ted Brick, Gen. Sales Mgr., UP 0-9161.

**GROVE VALVE & REGULATOR CO.,** 6529 Hollis St., Oakland 8, Calif.

• SPECIALTIES—Pressure - reducing and back pressure regulators for fuel and oxidizer tanks at pressures to 10,000 psi; panel mounted pressure reducing and relief regulators for test consoles and checkout systems; hand operated, motor operated or solenoid operated units for rapid load and vent; stainless steel ball valves for 6,000 #psi helium service; 2½ inch valves for water cooling of flame deflector aprons

• CONTRACTS—6000-psi stainless steel gas pressure reducing regulator for fuel transfer system of Saturn booster; pressure regulators for Polaris launch system; pressure regulators for Titan fuel transfer system.

• LITERATURE—General Catalog of Pressure Controls (No. **1273** on Card).

• CONTACT—K. F. McIntire, Prod. Mgr., OL 5-7700.

**GRUMMAN AIRCRAFT ENGINEERING CORP.,** Bethpage, N.Y.

• SPECIALTIES—Vans, housing telemetry for flight test programs; automatic checkout equipment for electronic systems; trainers and test simulators; maintenance trainers; weapon systems trainers in flight simulators. GSE testing and monitoring in development of orbiting astronomical observatory for NASA telemetering, checkout trainers, test simulators, etc., for WLF, A to F-1 Intruder, and Mohawk.

• CONTACT — Business Develop. Board, LR 5-0574.

**G V CONTROLS INC.,** 101 Okner Parkway, Livingston, N.J.

• SPECIALTIES—Electronic and thermal time delay veleys; electrical thermostats; Voltage Sensers and Regulators

• LITERATURE—Electronic Timing Devices (No. **1277** on Card); Thermal Timing Relays (No. **1278** on Card); Electrical Thermostats (No. **1279** on Card).

• CONTACT—R. F. Stockton III, Gen. Sales Mgr., WY2-6200.

**HADCO ENGINEERING CO.,** 2861 E. Slauson Ave., Huntington Park, Calif.

• SPECIALTIES — Support trailers 200 to 300 pounds capacity to 75,000 pounds; handling trailers; running gear for military trailers.

• CONTRACTS — Carrying trailer for Sidewinder; curing trailer for Minuteman; Mandrel trailer for Minuteman.

• LITERATURE—Running Gear & Ground Handling Equipment Catalog (No. **1280** on Card).

• CONTACT — C. R. Lancaster Service Mgr., LU 2-8251.

**HALLAMORE ELECTRONICS DIV., THE SIEGLER CORP.,** 714 N. Brookhurst Ave., Anaheim, Calif.

• SPECIALTIES — Launch control and checkout equipment; video monitoring systems.

• CONTRACTS—Launch and checkout equipment for Atlas silo; GSE for Sergeant; video systems for monitoring Titan ground checkout.

• LITERATURE—Phase-Lock Eqpt (No. **1281** on Card); Video Systems (No. **1282** on Card); Launch-Control and Checkout Equipment (No. **1283** on Card).

• CONTACT—J. Flock.

**THE HALLICRAFTERS CO.,** 4401 W. Fifth Ave., Chicago 24, Ill.

• SPECIALTIES—Maintenance and checkout of airborne systems, particularly the operating parameters of liquid and air-cooled countermeasure transmitters; test equipment for specialized components such as semiconductors and tubes for which no commercial testers are available; coolant pumping and filtering systems; hydraulic systems testers; target generators and jamming simulators airborne simulators to process ground radar signals to simulate incoming ICBM.

• CONTRACTS—GSE for maintenance and checkout of liquid-cooled and air-cooled countermeasures transmitters for B-52 subcontract from Convair for portion of Azusa transponder.

• LITERATURE — Electrical Cable Test Set (No. **1284** on Card); RF Calorimeter (No. **1285** on Card); Diode Tester (No. **1286** on Card).

• CONTACT—William Peugh, Asst. Sales Mgr., VA 6-6300.

**HAMILTON STANDARD DIV., UNITED AIRCRAFT CORP.,** Windsor Locks, Conn.

• SPECIALTIES — Propellant fuel-handling and transfer systems; liquid transfer carts; mobile probe-type jet engine starters; mobile air traffic control towers; ground cooling units and air conditioners; fuel accessory test stands; electronic test stands; propeller checkout stands wiring checkout carts.

• CONTRACTS — Guidance control air conditioner for Titan I; propellant temperature control units for Titan II; propellant transfer control units for Titan II.

• LITERATURE — GSE Capability Brochure (No. **1287** on Card); Product Data Sheets (No. **1288** on Card).

• CONTACT—A. H. Larkins, Sales Mgr., NA 3-1621 Ext. 440.

**HARMAN EQUIPMENT CO.,** 3604 E. Olympic Blvd. Los Angeles 23, Calif.

• SPECIALTIES—Porous metal for lox, UDMH, RP-1, hydrogen, nitrogen, helium, etc., for missile loading.

• CONTRACTS—Filters for loading skids in Atlas E and F silo, Titan I, and Saturn Complex 36.

• CONTACT—F. Van Zant, Cont. Administr., AN 1-4113.

**HAZELTINE CORP.,** Little Neck 62, N. Y.

• SPECIALTIES—Depot test facilities for radar MTI or AMTI Systems; specialized test equipment for SFF systems including checking of coders and decoders and computers; Automatic and semi-automatic test sets for modules and sub-assemblies.

• CONTRACTS — Depot GSE for APS-95 radar systems; module test set for NTD5 test equipment for IFF systems.

• LITERATURE - GSE Brochure (No. **1289** on Card).

# NEW!
# EXTENSION
# SWIVEL FITTINGS

PATENT APPLIED FOR

OFFERS 360° ROTATION

PROVIDES EXTENSION AND CONTRACTION OF SWIVEL END

COMPENSATES FOR THERMAL EXPANSION & CONTRACTION

DUMONT ENGINEERING has developed a new pressure balanced, low torque swivel fitting which is capable of accepting extension and retraction of its rotating end. This particular assembly achieves a full 6" extension without leakage, under high or low pressure service. In the ¼" tube size it is less than 10" in length and only ¾" in diameter. The unit offers a light weight solution in applications where it is necessary to contract a section of fluid system within an enclosure in order to seal that enclosure after internal connections have been completed. The extension feature also provides built-in compensation for linear movement due to thermal expansion or contraction.

The unit offers full 360° rotation of the swivel end and will operate at temperatures from —65° to +300°F. and pressures up to 5000 P.S.I. It is pressure balanced and therefore not subject to separation forces. The force required to extend or retract the rotating end is less than 8 lbs. when not pressurized. In a hydraulic system at 3000 P.S.I., the force is less than 14 lbs. for either rotation or extension of the swivel end. Pressure drop in the ¼" tube size is less than 5 P.S.I. at 1.2 G.P.M. flow of MIL-H-5606 hydraulic fluid at 70°F.

**The unit can be manufactured in various configurations, sizes, and fitting ends. For complete information and specifications, write or phone:**

**DUMONT ENGINEERING CO.**

Department S-4

1401 FREEMAN AVE. • LONG BEACH, CALIFORNIA

PHONE: SPruce 5-1131 • GEneva 3-4931

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• CONTACT—R. B. Pond, Mgr., FR 1-2300.

**HIGHLAND ENGINEERING CO.,** 1736 Berkeley St., Santa Monica, Calif.

• SPECIALTIES—Air Conditioning, hydraulic system, pneumatic systems, and ground handling equipment.

• CONTRACTS—Electric motor driven trailer 11½ ton air conditioner for B-52; stationary twin system hydraulic checkout stand for Navy; Crane and Davit assemblies for Nike Zeus acquisition and tracking radar antennas.

• LITERATURE—Engineering catalog (No. **1290** on Card); GSE Specialties (No. **1291** on Card); Manufacturing Facilities (No. **1292** on Card).

• CONTACT—B. E. Alvey, Cont. Administer, EX 5-0665.

**HOFFMAN ELECTRONICS CORP.,** 3761 S. Hill St., Los Angeles 7, Calif.

• SPECIALTIES—Trainers and test facilities for Tacon radio navigation sets; ramp and bench test equipment.

• CONTRACTS—Ramp and bench test equipment for B-47, B-52, B-58, and F-104.

• LITERATURE—Agree Reliability in Action (No. **1293** on Card); Tacon Test Equipment Data Package (No. **1294** on Card)

• CONTACT—H. P. Briggs, Ad. Mgr., RI 7-4488 Ext. 777.

**HOFFMAN ENGINEERING CORP.,** 9th & Tyler St., Anoka, Minn.

• SPECIALTIES—Welded sheet steel (oil, dust, and water tight) enclosures; panel and terminal enclosures; pushbutton boxes; control consoles wire-ways and troughs; RFI shielding.

• CONTRACTS—Units for Douglas, Rocketdyne, Martin.

• LITERATURE—Condensed Catalog (No. **1295** on Card); User Catalog (No. **1296** on Card); Product Bulletins (No. **1297** on Card).

• CONTACT—L. Bell, Sales Mgr., HA 1-2240.

**HOGAN FAXIMILE CORP.,** 635 Greenwich St., New York 14, N.Y.

• SPECIALTIES—High-speed digital printer plotters and facsimile systems; electrolytic recording paper; microfilm remote retrieval systems; digital event recorder, and analyzers; hard copy radar displays; ultrasonic test recording paper; oceanographic and spectrum analyzer displays.

• CONTRACTS—Battery plotter for Nike-Zeus high speed digital printer plotter for Minuteman; microfilm retrieval facsimile for BuShips.

• LITERATURE—Digital Printer Plotter Catalog (No. **1298** on Card); Document Retrieval Facsimile System (No. **1299** on Card); Information on Faxpaper (No. **1300** on Card).

• CONTACT—J. V. Hogal, Sales Mgr., CH 2-7855.

**HOKANSON, C. G. CO. INC.,** 2140 Pontius Ave., Los Angeles, Calif.

• SPECIALTIES—Mobile and skidmounted air conditioners for aircraft and missiles; heating, cooling, and drying units; air and nitrogen conditioning.

• CONTRACTS—Guidance pod air conditioners for Atlas silo, Titan II, and Centaur; water chillers for Minuteman guidance compartment.

• LITERATURE—Capabilities and Facilities (No. **1301** on Card); Tailored Atmosphere (No. **1302** on Card); Leader in Missile Support Air Conditioning (No. **1303** on Card).

• CONTACT—R. H. Hilmer, Exec. V-P, BR 2-3268.

**LUDWIG HONOLD MFG. CO.,** Chester Pike & Folcroft Ave., Folcroft, Pa.

• SPECIALTIES—Shipping containers and skids; precision sheet metal and light alloy fabrications.

• CONTRACTS—Shipping skid for MK-6 Scoring Kit, Antenna container for Advent; electronics cabinet for Hawk.

• CONTACT—F. N. Feer, Jr., Chf. Engr., LU 3-6800.

**HOUDAILLE INDUSTRIES, INC., BUFFALO HYDRAULICS DIV.,** 537 East Delavan Ave., Buffalo 11, N.Y.

• SPECIALTIES—Heavy-duty rotary hydraulic shock absorbers for controlling damaging vibrations in vehicle and lading suspension systems; rotary hydraulic actuators for power-driven functions such as lifting, lowering, rotating, postioning, opening, closing and swinging.

• CONTRACTS—Units for Minuteman missile transporter units for Air Force tactical system test set.

• LITERATURE—Rotary Shock Absorber Catalog (No. **1501** on Card); Precision Hydraulic Rotary Actuator Catalog (No. **1502** on Card).

• CONTACT—A. C. Crossen, Asst. Sales Mgr., TX 5-8000.

**HOWELL INSTRUMENTS, INC.,** 3479 W. Vickery Blvd., Ft. Worth 7, Texas.

• SPECIALTIES—Instrumentation for indicating and recording engine parameters such as temperature, speed, fuel flow, pressure, etc. with provisions for retransmission of this data for systems control applications.
• CONTRACTS—Functional checkout and sequential prelaunch programming for Mace; digital voltmeter for calibration of Titan signal conditioning equipment; EGT indicator for GAM-72 engine checkout console.
• LITERATURE—Portable Digital Voltmeter (No. **1503** on Card); Autotemp Comprehensive Instrumentation (No. **1504** on Card).
• CONTACT—L. H. Becker, Sales, ED 6-7411.

**HUFFORD DIV., THE SIEGLER CORP.,** 1700 E. Grand Ave., El Segundo, Calif.
• SPECIALTIES—Transrector vehicles for handling rocket motor cases; hydraulic systems for missile transportation, mating and erection trailers; hydraulic actuators and decelerating cylinders for launchers; hydraulic, pneumatic and electrical servicing panels; large antenna systems.
• CONTRACTS—Hydraulic, pneumatic and electrical servicing panels for Centaur; sixty foot antenna system for Midas; hydraulic system for Atlas.
• LITERATURE—Product Brochure (No. **1505** on Card); Facilities Brochure (No. **1506** on Card).
• CONTACT—L. H. Sanderfer, Sales Mgr., SP 2-1151 Ext. 291.

**HUMIDIAL CO.,** Box 464, Colton, Calif.
• SPECIALTIES—Humidity indicating cards and plugs for missile containers and components.
• CONTRACTS—Units for Atlas and Titan; missile cases for Zero Mfg.
• LITERATURE—Humidity Indicator Catalog (No. **1507** on Card); Product Drawings (No. **1508** on Card).
• CONTACT—Bruce Blinn, TA 5-1793.

**HYDRA-POWER CORP.,** 10 Pine Court, New Rochelle, N.Y.
• SPECIALTIES—Hydraulic control valves, actuators, servos and manifolded components.
• CONTRACTS—Launching control valves for Titan I silo.
• LITERATURE—Facilities and capabilities (No. **1509** on Card).
• Contact—E. D. Holland, V. P. Sales, NE 2-2200

**HYDROMATICS, INC.,** 5 Lawrence St. Bloomfield, N.J.
• SPECIALTIES—Manual, pneumatic, and electric motor actuated ball valves to control missile propellants in stationary launch site installations and on fueling trailers; flow control of fuels and oxidizers including liquid oxygen, liquid nitrogen, and liquid hydrogen.
• CONTRACTS—Fuel control valves for Atlas silos; fuel control valves Cape Canaveral Complex #6; fuel control valves for Saturn.
• CONTACT—J. W. Harris, Sales Mgr. PI 8-7000.

**INDUSTRIAL CONTROL CO.,** Central Ave., & Pinelawn, Farmingdale, N.Y.
• SPECIALTIES—Servo testers and signal generators for automatic checkout of missile servo loops; sub-systems such as servo indicators, digitizers, etc.
• LITERATURE—General Catalog (No. **1510** on Card).
• CONTACT—G. M. Attura, Chief Eng., MY 4-3000.

**INDUSTRIAL DIV., MOOG SERVOCONTROLS INC.,** East Aurora, N.Y.
• SPECIALTIES—Electro-hydraulic servo systems for missile launcher direction, radar tracking antemal control, and vehicle motion simulation.
• CONTRACTS—Servo-valves for Terrier and Tartar missile launchers; valves for RCA radar antennae drives; servovalves for Polaris underwater motion simulator.
• LITERATURE—Electrohydraulic Servomechanisms (No. **1511** on Card); Electronic Modules Catalog (No. **1512** on Card); Industrial Servovalves Catalog (No. **1153** on Card).

**INDUSTRIAL ELECTRICAL WORKS, INC.,** 1509 Chicago St., Omaha 2, Neb.
• SPECIALTIES—Stainless steel high pressure hose reels for static missile checkout; multiple conductor explosion-proof electric cable reels for missile checkout systems; electric power reels.
• CONTRACTS—Satic checkout reels for Atlas; service structure elevator and gentry crane reels.
• LITERATURE—Reel and Slip Ring Missile Applications


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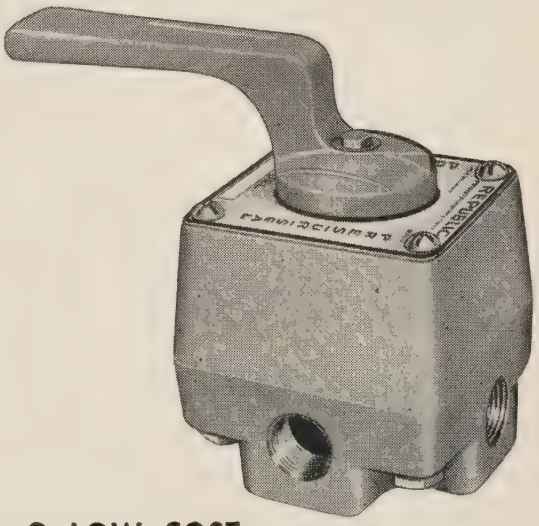
*New* design

3000 psi

PRES-UR-SEAL

SELECTOR VALVE



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- EASY TURNING
- LONG LIFE
- AIR OR OIL SERVICE

New Pres-Ur-Seal design brings this valve into "cost" line with spool and similar type valves, and has many other advantages inherent in the balanced-seal type. For lubricated air service to 2000 psi; oil to 3000 psi. Max. internal leakage, oil—1 drop per minute. Panel mounting. Side ported. Internal pipe threads, ¼" to 1".

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VALVES

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(No. **1514** on Card).
• Contact—J. C. Costello, 341-4600.

**INDUSTRIAL TECHNOLOGICAL ASSOCIATES, INC.,** 2108 Payne Ave., Cleveland 14, Ohio.
• SPECIALTIES—Ground support concepts for missiles and space vehicles; logistics systems; handling concepts and design of equipment; transportation; and layout of storage, assembly and firing areas.
• CONTRACTS — Transportation, storage and handling of all Navy missiles including Asroc, Boar, Bullpup, Hawk, Mighty Mouse, Polaris, Sidewinder, Sparrow, Talos, Tartar, Terrier, Weapon A and Zuni.
• LITERATURE—Capabilities and Facilities (No. **1515** on Card).
• CONTACT—J. M. Stewart, PR 1-4151.

**INTERCONTINENTAL DYNAMICS CORP.,** 170 Coolidge Ave., Englewood, N.J.
• SPECIALTIES—Pilot-static air data calibrators and testers.
• CONTRACTS—Air data tester for Navy.
• LITERATURE—Air Data Calibrators (No. **1516** on Card).
• CONTACT—F. M. Winnai, Mkt. Mgr.

**INTERSTATE ELECTRONICS CORP.,** 707 E. Vermont Ave., Anaheim, Calif.
• SPECIALTIES —Instrumentation arrays for missile test firings; launch-complex instrumentation systems, telemetry systems, timing and control systems for shore, ship and submarine; television-monitoring systems for shore and ship; optical and photographic data-gather systems; fire-control recording systems; trajectory-measuring systems and range-safety systems for ship; satellite receiving stations communications and missile flight safety checkout systems; data inspection equipment.
• CONTRACTS — Instrumentation for Polaris Class 598 and 616 submarines; Polaris shore based instrumentation at Atlantic Missile Range.
• LITERATURE—Time Code Generator Data Sheets (No. **1517** on Card); VLF Timing Receiver and Correlator Data Sheet (No. **1518** on Card); Tracking Filter Data Sheets (No. **1519** on Card).
• CONTACT—Dr. J. F. Jenkins, Jr., Dir. of Engrg., PR 2-2222 Ext. 383.

**ITT FEDERAL LABORATORIES DIV., INTERNATIONAL TELEPHONE & TELEGRAPH CORP.,** 500 Washington Ave., Nutley 10, N.J.
• SPECIALTIES—Automatic test equipment for all types of missile systems at launch site or depot level; Tacan test equipment.
• CONTRACTS—Vate (Versatile Automatic Test Equipment; automatic test equipment for Bomarc; Eglin Range design and instrumentation
• LITERATURE—Tacan Test Equipment (No. **1520** on Card); Electrical Launching Equipment (No. **1521** on Card); Satellite-Doppler Tracking Station (No. **1522** on Card).
• CONTACT—A. Smolen, Dir. of Engrg. Sales., NO 1-1100.

**JACK & HENTZ DIV., THE SIEGLER CORP.,** 17611 Broadway, Cleveland 1, Ohio.
• SPECIALTIES—Design and production of electric and hydraulic leveling and erecting actuators, including analysis of requirements. Electric drive systems for GSE vehicles, integrating vehicle propulsion system with auxiliary power for communications, guidance, erection, and launch. Generating systems producing precisely controlled frequencies. Quick-connect fluid couplings for remote or sequenced transfer, cooling, and pneumatic landing. Automatic test equipment for these systems.
• CONTRACTS — Pershing transporter-erector-launch actuators. Quick-connect couplings for cooling air (umbilical) on Mace.
• LITERATURE—Actuator Product Data Sheets (No. **1701** on Card); Vehicle Electric Drive Systems (No. **1702** on Card); Triggerlock-Couplings (No. **1703** on Card).
• CONTACT—N. R. Kidder, Mgr., Mkt. Serv., MO 2-1000.

**JAMES, POND & CLARK, INC.,** 2181 E. Foothill Blvd., Pasadena, Calif.
• SPECIALTIES—Check, shutoff, relief and other leakproof valves.
• CONTRACTS—Check valves for Titan and Atlas; shutoff valves for Atlas.
• LITERATURE—0-5000 psi Check Valves (No. **1523** on Card); 10-2400 psi Relief Valves (No. **1524** on Card). 0-6000 psi Shutoff Valves (No. **1525** on Card).

**K. W. JOHNSON & CO., INC.,** 1825 Webster St., Dayton 4, Ohio.
• SPECIALTIES—Shock and vibration control devices.
• CONTACT—R. D. Tobey, Sales Mgr., BA 4-1078 Ext. 3.

**JOY MANUFACTURING CO.,** 333 Oliver Bldg., Pittsburgh 22, Pa.
• SPECIALTIES—Air-cooled, portable, and stationary compressors for compressing air, nitrogen, or helium to 10,000 psi.
• CONTRACTS—150 scfm and 8500 psi helium compressors for Air Force.
• LITERATURE—High Pressure Compressors (No. **1526** on Card).
• CONTACT — H. R. Behrendt, Group Supv., TR 2-7221.

**KAHN & COMPANY, INC.,** Box 516, Hartford 1, Conn.
• SPECIALTIES—Hydraulic, pneumatic, and electrical test equipment, providing low and high pressure air and gas supplies for purging and pressurizing.
• CONTRACTS—Dehydration high pressure air supply for Polaris; pressurizer dryer systems for Air Force.
• LITERATURE—Dehydration of Air and Gases (No. **1527** on Card); Pressurizing with Oil Free Air (No. **1528** on Card); Speed Related Sequencing Control (No. **1529** on Card).
• CONTACT—Robert Sheldon, V-P JA 9-8643 Ext. 23.

**KAISER ENGINEERS,** 300 Lakeside Dr., Oakland 12, Calif.
• SPECIALTIES—Preparation of site design criteria and concepts; construction plans and specifications; engineering studies, site selection investigations; procurement, expediting, construction and construction management, etc.
• CONTRACTS—Construction of operational launch complex including silos, equipt. terminals, propellant terminals, antenna silos, control center, power house, portal silo and filtration structure for Titan; studies of alternative design and concepts for operational launcher system, preparation of design criteria and concepts for static test facilities for Minuteman; currently performing classified engineering services in connection with Atlas, Scout and Aerobee.
• CONTACT—J. W. Desmond, Dev Eng., CR 1-4494.

**KEARFOTT DIV., GENERAL PRECISION, INC.,** Little Falls, N. J.
• SPECIALTIES—Manual and automatic ditigal and analog test equipment for gyros, gyro-platform reference systems, inertial guidance systems, and radar; manually operated and automatic consoles and modules for testing servo systems, amplifiers and related devices, gyroscopic instruments, and mechanical and electromechanical assemblies; component test equipment for the laboratory, production line or field.
• CONTRACTS — Celestial/terrain viewing system for A3J Vigilante flight simulator trainer; operational checkout, maintenance, and overhaul test equipment for the AN/AJN-8 heading/vertical reference set in the B-52H; general purpose synchro and resolver tester for the Navy.
• LITERATURE—Ground Support Equipment Capabilities (No. **1530** on Card); Automatic Synchro and Resolver Tester (No. **1531** on Card); High Accuracy Precise Angle Indicators (No. **1532** on Card).
• CONTACT—Saul Liss, Mgr., Special Prod. Sales, CL 6-4000 Ext. 304.

**KIDDE AERO-SPACE DIV., WALTER KIDDE & CO., INC.,** 14 Main St., Belleville 9, N.J.
• SPECIALTIES—Fire-overheat detection and extinguishing systems; portable high-pressure peneumatic systems; ball bearing screw thread actuators.
• CONTRACTS—Overheat detection system for Saturn's eight engines while being static tested.
• LITERATURE—Portable 5000 psi Pneumatic Systems (No. **1533** on Card).
• CONTACT—B. L. Eisenberger, Mgr., Pneumatics Section, PL 9-5000.

**WALTER KIDDE & COMPANY, INC., INDUSTRIAL & MARINE DIVISION,** 14 Main St., Belleville 9, N.J.
• SPECIALTIES—Fixed carbon dioxide fire extinguishing systems; first aid fire equipment.
• CONTRACTS—Hound Dog.
• LITERATURE—Architect's Manual for Engineered $CO_2$ Systems (No. **1534** on Card); General Catalog (No. **1535** on Card); Fire Brigade Manual (No. **1536** on Card).
• CONTACT—L. C. Bailey, Sales Mgr., PL 9-5000.



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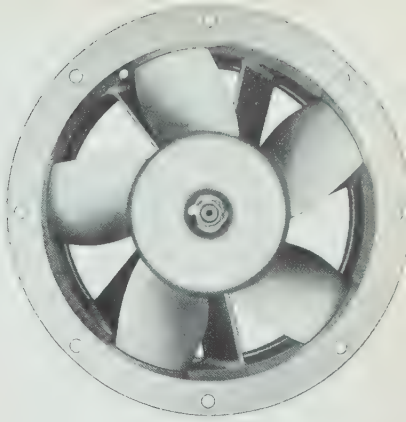
MOVING
AIR
IS
CHILD'S
PLAY

CONTROLLING
IT
TAKES
AN
EXPERT



In years of specializing in air moving and cooling, at times we have been undersold, outmaneuvered and outtalked. But we've seldom been outdesigned or outperformed. Sooner or later most air moving problems come to Torrington. Brochure 102 proves why it should be sooner.

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**KIDDE ELECTRONICS LABORATORIES, WALTER KIDDE & CO., INC.,** 14 Brighton Rd., Clifton, N.J.

• SPECIALTIES—Transportable hydraulic shops for testing and repairing hydraulic and pneumatic components in a controlled atmosphere; transportable electro-mechanical shops equipped with power and hand tools, work benches and storage cabinets; hydraulic driven electric power supplies.

• CONTRACTS—3rd and 4th echelon field maintenance equipment for Hawk; 1200 VA static inverter for RCA; hydraulic driven electric power supply for Naval Underwater Ordnance Station.

• LITERATURE — Capabilities in Ground Support Test of Automated Equipment (No. **1449** on Card); Hydraul-Driven Electric Power Supply (No. **1450** on Card); 1200 VA Static Inverter (No. **1451** on Card).

• CONTACT—Ed Osta, Sales Mgr., GR 5-2000.

**KIDDE ULTRASONIC & DETECTION ALARMS DIV., WALTER KIDDE & CO., INC.,** 14 Brighton Rd., Clifton, N.J.

• SPECIALTIES—Ultrasonic and photo-electric installations to detect intruders; pneumatic tubing and localized electric-operated type fire alarm systems.

• LITERATURE—Kidde Ultrasonic Alarms Systems (No. **1537** on Card); Prox-O-Larm Capacity Alarm (No. **1538** on Card); Lyne-O-Larm (No. **1539** on Card).

• CONTACT—Harry Hardeen, Dir., Sales & Mkt. Res., GR 2-5000.

**THE KLINE MANUFACTURING CO.,** Galena, Ohio.

• SPECIALTIES—Electric motor, engine, and turbine direct drive 5000 psi axial piston pumps with capacities of 5 to 120 gpm; constant volume and variable volume pumps for operation at —65°F. to +275°F.

• CONTRACTS—Pumps for Air Force MK-3 test stands; pumps for Sun Electric Corp. & Redco Corp. test stands; pumps for Titan II silo doors.

• LITERATURE—Hydraulic Pump Catalog (No. **1540** on Card); Hydraulic Motor Catalog (No. **1541** on Card).

• CONTACT—R. E. Teeghman, Dir. of Engr., WO 4-2911.

**KOHLER CO.,** Kohler, Wis.

• SPECIALTIES—500 W to 115 KW gasoline and diesel engine generating sets for stationary stand-by power service and for portable and mobile electric power on missile vans and trailers.

• CONTRACTS—Generating sets for Minuteman and Thor.

• LITERATURE—Sweet's Catalog Reprint (No. **1542** on Card).

• CONTACT—F. W. Nelson, Sales & Serv. Admin.

**KOLLSMAN INSTRUMENT CORP.,** 80-08 45th Ave., Elmhurst 73, N.Y.

• SPECIALTIES—Auto-collimators, optically-linked servos, single and multiple star simulators, photometers, optical calibrators, and encoders; track and trajectory computers, multiple target track recording and projection subsystems, character generators, auto-insertion remote plotting boards, digital display modules; air-data transducers, programmed pitot-static system testers, instrument calibrators; electronic servoed encoders, magnetic and solid state control amplifiers, analog and digital computers, indicators and simulators, servo and amplifier testers; astro tracker test stands, orthogonality testers; evacuation, purging, backfilling and desiccant drying fixtures.

• CONTRACTS—Test, overhaul and repair capabilities at flight-line, field and depot levels for B-52, GAM-77 Hound Dog, and B-58 Hustler.

• LITERATURE—Missile and Space Systems (No. **1543** on Card); Astronavigation (No. **1544** on Card); Product Bulletins (No. **1545** on Card).

• CONTACT—Robert Friedman, AGE Mgr., TW 9-5600.

**LABORATORY FOR ELECTRONICS, INC.,** 1079 Commonwealth Ave., Boston 15, Mass.

• SPECIALTIES—Electronic systems test and checkout systems particularly Doppler Radar navigation systems; microwave checkout and test equipment; Moving Target Indicator test equipment.

• CONTRACTS—AN/GPM-24 for F-105; MTI Test Sets; AN/GPM-24 for F-105.

• CONTACT—J. G. Prout, Jr.

**LANGLEY CORP.,** 310 Euclid Ave., San Diego 12, Calif.

• SPECIALTIES—Cryogenic, hydrocarbon, hydraulic, pneumatic components specializing in swivel joints, ball gimbals, valves, cylinders, mechanical assemblies and LOX cleaning.

• CONTRACTS—Main liquid oxygen fill and drain line, liquid oxygen topping lines, and main hydraulic valve actuating cylinder for Atlas.

• LITERATURE — Facilities Brochure (No. **1546** on Card); Cryogenic and Hydrocarbon Brochure (No. **1547** on Card); Hydraulic and Pneumatic Brochure (No. **1548** on Card).

• CONTACT — S. L. Sandelman, Chief Engr., CO 4-3181.

**LENZ CO.,** 3301 Klepinger Road, Dayton 1, Ohio.

• SPECIALTIES—Flare tube and O-ring seal tube fittings, pipe fittings, hydraulic accessories, and reusable hose fittings.

• CONTRACTS — GSE units for Talos and Asroc.

• LITERATURE—O-Ring Seal Tube Fitting Catalog (No. **1549** on Card); Engineering Dimensional Catalog (No. **1550** on Card); Reusable Hose Fitting Catalog (No. **1551** on Card).

• CONTACT — J. L. Lenz, Pres., CR 7-9364.

**WALLACE O. LEONARD, INC.,** 373 S. Fair Oaks Ave., Pasadena, Calif.

• SPECIALTIES — Mobile lox-Fuel tanking computers; lox-Fuel tanking computer test calibrator; regulators, check valves, relief valves, throttling valves.

• CONTRACTS—Jupiter, Saturn.

• LITERATURE—General Brochure (No. **1552** on Card); Outline Drawings (No. **1553** on Card); Specs (No. **1554** on Card).

**LIBRASCOPE DIV., GENERAL PRECISION, INC.,** 808 Western Ave., Glendale 1, Calif.

• SPECIALTIES — Data processing systems for control in missile and satellite tracking, combat centers, and continental or global communications networks.

• CONTRACTS—Proposals to government agencies.

• LITERATURE — Technical Data Brochure (No. **1555** on Card).

• CONTACT—F. Bristow, Press Rel. Mgr., CH 5-8711.

**LINDE CO.,** 270 Park Ave., New York 17, N. Y.

• SPECIALTIES — Super-insulated cryogenic liquid containers and storage tanks; liquid and gaseous trailers; transfer equipment such as vacuum insulated pipe, high pressure pumps, vaporizers, circulation systems; environmental chambers.

• CONTRACTS — Vacuum-insulated pipe with Linde super-insulation for transfer of Saturn liquid hydrogen; environmental chamber and liquid helium storage and circulation system for NASA space simulator; 40,000 cfhr and 3500 psig liquid hydrogen pumps and vaporizer for Douglas.

• LITERATURE—Cryogenic Fluids for Space Propulsion Systems (No. **1556** on Card); Experimental Performance and Selection of Cryogenic Rocket Insulation Systems (No. **1557** on Card); Cryogenic Tankage for Space Flight Applications (No. **1558** on Card).

• CONTACT—E. T. Keehan, Admin. Asst. to Genl. Mgr., LL 1-4020.

**LINK-BELT CO.,** Prudential Plaza, Chicago 1, Ill.

• SPECIALTIES — Retractable missile shelters; launching system service platforms.

• CONTRACTS — Retractable gantries and roof shelters for Atlas; retractable missile shelters for Thor.

• LITERATURE—Power Transmission Equipment (No. **1559** on Card); Roller Chain and Sprockets (No. **1560** on Card); Ball and Roller Bearings (No. **1561** on Card).

**THE LIQUIDOMETER CORP.,** 41-03 36th St., Long Island City 1, N.Y.

• SPECIALTIES — Propellant and cryogenic tank gauging equipment. Test equipment for electronic propellant and cryogenic gauging systems. Liquid-level controls for tank stored liquids.

• CONTRACTS — Bomarc: tank ground storage tanks contents gauges ($HNO_3$, JP-4, JP-X, UDMH). Titan II: Propellant tank contents gauges. Minuteman: Gauges for fuel oil tanks used for hot water and heating.

• LITERATURE—Bulletin 561: Tank Contents Gauges for Cryogenic materials (No. **1698** on Card). Bulletin 463A: Tank Contents Gauges (No. **1699** on Card) Bulletin 522A: Liquid Measurements in Pounds (No. **1700** on Card).

**LITTON SYSTEMS, INC., GUIDANCE & CONTROL SYSTEMS DIV.,** 5500 Canoga Ave., Woodland Hills, Calif.

• SPECIALTIES — Equipment for testing inertial navigation components and systems, and analog and digital computers; production line test, military depot repair, operational field test and maintenance; automatic checkout; trainers and test simulators.

• CONTRACTS—Equipment for test-

ing inertial navigation components and systems at every level of use for F-104G; Basic automatic checkout equipment (BACE) adapter drawers for testing inertial navigation-bombing systems used on A2F; digital computer component test equipment.

• LITERATURE—Computer Laboratory and Products (No. **1562** on Card); LN-3 Inertial Navigation System (No. **1563** on Card); Magnetic Storage Drum Memories (No. **1564** on Card).

• CONTACT—A. H. Orbuch, Dir. of Mktg.

**LOCKHEED ELECTRONICS CO.,** Route 22, Plainfield, N. J.

• SPECIALTIES—Displays for presentation of information for ground electronics equipment, for presentation of satellite position status, and for readout of reconaissance data for satellites.

• CONTRACTS—Trace countdown equipment for Polaris; human factors research display status board for Hanscom Field; Advent Control Center Display Systems.

• CONTACT—R. E. Williams, Mgr., PL 7-1600.

**LOCKHEED MISSILES & SPACE CO.,** Sunnyvale, Calif.

• SPECIALTIES—Checkout consoles and launch monitor and control consoles for satellites; ground handling items for ballistic missiles; propellant transfer tanks for space vehicles.

• CONTRACTS — Ground support and handling equipment for Agena satellites and for Polaris.

• CONTACT — Mgr., Aerospace Ground Equip., Van Nuys, Calif.

**THE LOVESTRAND COMPANY,** Southlawn Lane, Rockville, Md.

• SPECIALTIES—Aluminum handling equipment for solid propellant boosters; wheeled vehicles; fabricated metal storage containers; portable metal shelters; trailers, and special bodies for trailers.

• CONTRACTS — Electromechanical equipment for Polaris; solid propelland handling equipment for Iris; portable wood and metal working trailers for on-site use.

• LITERATURE—Photos of Products (No. **1565** on Card); Company Brochure (No. **1566** on Card).

• CONTACT—G. A. Hall, V-P & Gen. Mgr.

**LOVEJOY FLEXIBLE COUPLING CO.,** 4842 W. Lake St., Chicago 44, Ill.

• SPECIALTIES—Power transmission equipment; couplings to eliminate engine vibrations; universal joints.

• CONTRACTS — Ground support equipment for Bendix, Atlas, Western Electric.

• LITERATURE—Product Bulletins (No. **1567** on Card).

• CONTACT—Ray Giegerich, ES 9-3010.

**LUKENS STEEL CO.,** Coatesville, Pa.

• SPECIALTIES — Low-temperature steels for cryogenic storage and transport. High-tensile steels for construction, handling and transport facilities. Complete range of carbon steels. Fabrication of these steels.

• CONTRACTS — Blast doors and door jams and main support girders for silo at Titan base.

• CONTACT—J. D. Heffernan, DU 4-6200.


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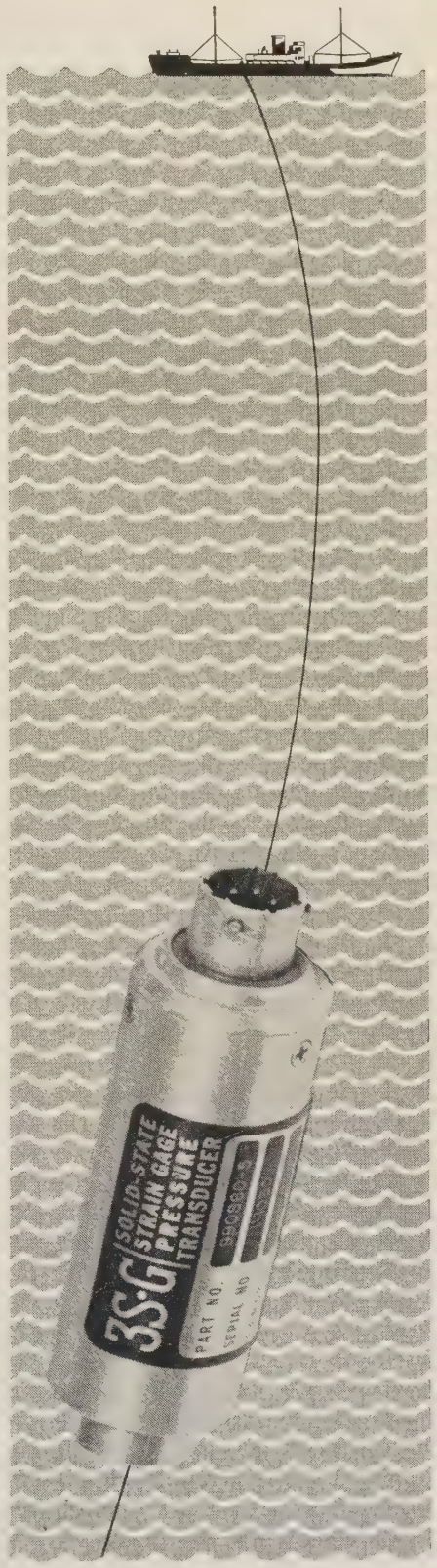


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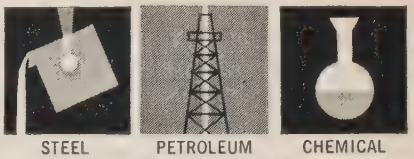
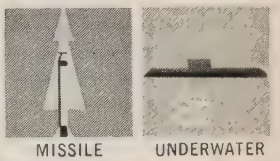
For remote pressure measurement via long lines—under water or above ground—you need a transducer that delivers a high-output signal without additional amplification. The only answer is the new Fairchild 3S-G. It has a 5 v. d.c. output. And it uses semiconductor materials with piezoresistive characteristics as a sensing element.

Extraordinarily accurate (±.003%/degree F error band is not uncommon) in the roughest environment, the tough 3S-G has infinite resolution, self-contained calibration, temperature compensation, and unexcelled repeatability. It is also available with low output (5mv. to 5 v. d.c.), low-pressure gage and absolute (0-10 to 0-100 p.s.i.), high-pressure gage and absolute (0-100 to 0-10,000 p.s.i.), and high-line low-differential (±10 to ±10,000 p.s.i.d.). All versions operate from −65° to 250°F in practically all gaseous and liquid media, including liquid oxygen, strong alkalies, corrosive acids, and high-energy fuels. All are designed to replace strain-gage pressure transducers now being used by industry and the military.

For more information about the 3S-G silicon-semiconductor strain-gage pressure transducer, write Dept. 51 SA.




wide application in control systems for defense & industry

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• CONTRACTS — Blast doors and door jams and main support girders for silo at Titan base.
• CONTACT — J. D. Hefferman, DU 4-6200.

**LUNDY ELECTRONICS & SYSTEMS, INC.,** Glen Head, N. Y.
• SPECIALTIES—Manual and automatically programmed electromechanical, electro-hydraulic and electronic test equipment for aircraft and missile components and systems; flight line and depot level test and checkout equipment.
• CONTRACTS—Solid-state automatically programmed checkout equipment for flight line use and test benches for depot level component and system test of Boeing B-52H aircraft wing chaff dispensing system; test equipment for Tape Programmer on US5D Surveillance Drone; test equipment for magnetic sequencing switch on F4H-1.
• LITERATURE—GSE Background and Capabilities Brochure (No. **1568** on Card).
• CONTACT—R. C. Barbato, OR 6-1440.

**LYCOMING DIV., AVCO CORP.,** 550 S. Main St., Stratford, Conn.
• SPECIALTIES—Mechanical and electrical GSE and GOE; equipment to transport, assemble, test and monitor re-entry vehicles; simulators and trainers.
• CONTRACTS—Ground handling and electrical checkout equipment for Titan-Atlas (E&F) Mark 4 Re-entry vehicle subsystem; ground handling and electrical checkout equipment for Minuteman Mark 5 Re-entry vehicle subsystem; equipment to monitor and set fuze in Mark 4 GOE re-entry vehicle prior to launch.
• CONTACT—C. D. Flanigen, Dir. of Engrg., DR 8-8211 Ext. 351, 352.

**LYNCOACH & TRUCK COMPANY, INC.,** 443 Chestnut St., Oneonta, N. Y.
• SPECIALTIES—Trailers and semi-trailers; heating, air conditioning, and duct work for trailers; wiring and installation of electrical system including harnesses leading to equipment racks.
• CONTRACTS—Antennae trailers for Hawk; triple launch control trailers for Jupiter; guidance and control trailers for Redstone.
• LITERATURE — Company Brochure (No. **1569** on Card).
• CONTACT — F. E. Humphreys, V-P & Chief Engr., GE 2-2900 Ext. 6.

**MADIGAN ELECTRONIC CORP.,** 200 Stonehinge Lane, Carle Place, N. Y.
• SPECIALTIES — Visual distance computers; training device and simulators.
• CONTRACTS—MAD signal trainer for Navy; communications system installation for Signal Corps.
• CONTACT—Donald Arany, Dir. of Engrg., ED 4-2500.

**MAGNESIUM CO. OF AMERICA,** 155 S.E. 10th Avenue, Hialeah, Fla.
• SPECIALTIES—Vans, pit covers, trailers, portable stands and scaffolds, trucks, etc., in aluminum and magnesium.
• CONTRACTS—Aluminum trailer truck for transporting Titan; missile trailer truck for Navy; launch pad sites flame pit covers for Nike and Titan.
• LITERATURE—Magnesium Portable Yard Ramps (No. **1570** on Card); Aluminum 4-wheel Platform Trucks (No. **1571** on Card); Collapsible Aluminum Cargo Containers (No. **1572** on Card).
• CONTACT—J. D. Anderson, V-P, Sales, TU 7-8117.

**MARINE & ORDNANCE DEPT., VICKERS INC.,** 172 E. Aurora St., Waterbury 20, Conn.
• SPECIALTIES — Hydraulic systems, components and drives for missile service towers, silo elevator and roof actuation systems; hydrostatic transmissions for special purpose vehicles; electro-hydraulic servo systems and components for automatic missile handling and storage systems; hydraulic power units, cylinder actuators and controls for launcher erector systems; hydrostatic transmissions for transporter-launcher erector vehicles; fixed and mobile electro-hydraulic power units for GSE; electronic cooling systems; electro-hydraulic test and checkout stands; components and systems for automatic checkout; hydraulic and electro-hydraulic servo transmissions and components for azimuth, elevation and traverse drives for radar antennas, theodolite and theodolite mounts, and similar radar, electronic and optical tracking and communications drives.
• CONTRACTS—Hydrostatic drive system B-52 Towing Tug; large buffer hydraulic cylinders for Titan silo elevator and axial piston hydraulic motors for the elevator drive systems; electro-hydraulic servo drives for the azimuth, elevation and drive systems for the Nike-Zeus Target Tracking and Missile Tracking radars.
• LITERATURE—B-52 Towing Tug Hydrostatic Drives (No. **1573** on Card); Missile Erector Control Systems (No. **1574** on Card); Hydraulic Systems for GSE (No. **1575** on Card).
• CONTACT—R. J. Mitchell, Sales Mgr., PL 6-3684.

**THE MARTIN CO.,** Electronics Div., Baltimore 3, Md.
• SPECIALTIES—automatic tactical equipment and manual R&D launch monitoring, control and checkout systems; propellant handling and cryogenics; missile ground handling equipment, transporters, shelters; seaplane beaching gear, ground power for hardsite installations; operational and maintenance missile trainers.
• CONTRACTS — launch control, checkout, and trainers for Titan, design criteria study for automatic test and checkout systems for Air Force and design for a universal automatic ground checkout system; launch, handling, power, and maintainance equipment for Mace.
• LITERATURE—Martin GSE (No. **1801** on Card). Checkout Equipment Design Criteria (No. **1802** on Card). Trainer Capability at Martin-Baltimore (No. **1803** on Card).
• CONTACT — John Hopkins, Program Plan Mgr., MU 7-3800 Ext. 9921 (Mail No. F3079).

**MARTIN ORLANDO,** Box 5837, Orlando, Fla.
• SPECIALTIES—All specialties developed as part of major weapon or electronics systems.
• CONTRACTS—Complete GSE systems for Pershing, Lacrosse, and Army FADMDS.
• CONTACT — J. Pritchard, GSE Chief, CH 1-2411.

**MASON-NEILAN DIV., WORTHINGTON CORP.,** Nahatan St., Norwood, Mass.
• SPECIALTIES—Automatic control valves and instrumentation for propellant loading systems cryogenic and other fluids.
• CONTRACTS—Propellant loading system valves Atlas; valves and control instrumentation for Titan I and II.
• CONTACT—G. F. Schlechter, Mgr., Sales Specs. Dept., 762-4600.

**MAXSON ELECTRONIC CORP.,** 475 Tenth Ave., New York 18, N.Y.
• SPECIALTIES—Electronic, electromechanical, electrohydraulic GSE including missile and stores ground handling equipment, subsystems, test equipment, missile launching system, and automatic checkout equipment.
• CONTRACTS—GSE for MA-2 system; safety and arming devices for ground ordnance; adaption kits to provide safing, arming, fuzing and energy sources for control of nuclear warheads.
• CONTACT—E. J. Croni, Asst. Dir. of Mil. Sales.

**McCORMICK-SELPH ASSOCIATES, INC.,** Hollister, Calif.
• SPECIALTIES—Auxiliary power units; pyrindicator indicators; simulating ordnance firing to train test crews; rotary exploding bridgewire power supply.
• CONTRACTS—Units for Martin, Pyrodyne and Stratos.
• LITERATURE—Pyrindicator indicators (No. **1304** on Card); Exploding Bridgewire Current Shunt (No. **1305** on Card); Exploding Bridgewire Firing Module (No. **1306** on Card).

**McDONNELL AIRCRAFT CORP.,** Box 516, St. Louis 66, Mo.
• SPECIALTIES — Blockhouse, checkout, and monitoring equipment; launch checkout trailers, telemetry trailers, ultra high pressure oxygen checkout equipment, automatic stabilization control checkout fixtures, and hydrogen peroxide checkout trailers; ground power and cooling equipment; hydraulic and power supply carts; trainers and flight simulators.
• CONTRACTS—Complete support for F 101 with exception of the fire control system, CADC system, engine, and instruments; complete support for F4H with exception of the engine and fire control system; complete support of Mercury space capsule.
• CONTACT—J. A. Horn.

**M-D BLOWERS, INC.,** 100 Fourth St., Racine, Wis.
• SPECIALTIES—Oil free high pressure rotary positive blowers with 2 to 70 PSIGG systems and capacity to 4000 cfm; oil free vane type pumps for capacities up to 4 scfm and pressures to 20 psig.
• CONTRACTS—Mace air cooler; dry air pump for B-58 and F-106 ground supply air conditioner.

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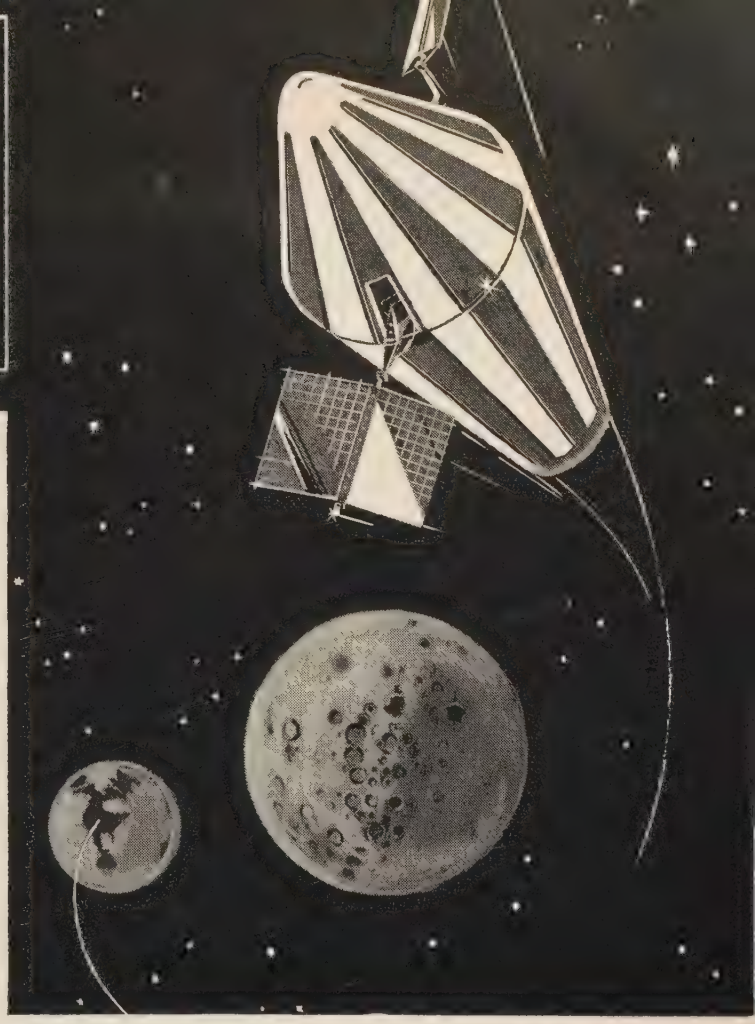

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Over the years, as Beech Aircraft Corporation has constantly developed its capabilities in the fields of design, development, fabrication and testing, it has acquired equipment, skills and experience that has enabled Beech to make invaluable contributions to the solution of many challenging problems related to the missile and aerospace age.

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Mr. T. Bruce Cooper
Manager, Southeast Area
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• LITERATURE—3 - Lobe Rotary Positive Blower Bulletin (No. **1307** on Card); Dry Air Pump Bulletin (No. **1308** on Card); Standard Duty Blower Bulletin (No. **1309** on Card).

**MEG PRODUCTS DIV., MANDREL INDUSTRIES,** 1238 Weller St., Seattle, Wash.

• SPECIALTIES — Cable assemblies and harness, with molded unctions or connectors; specialists in neoprene, silicone, and polyurethene colding; plastic injection molding.

• CONTRACTS—GSE umbilical cables for Polaris; instrumentation cables for aircraft and project mercury; umbilicals and landline cables for Minuteman test firings.

• LITERATURE—Low Temperature Neoprene Molding Tech Data (No. **1310** on Card); Facilities Brochures (No. **1311** on Card); Test Data (No. **1312** on Card).

• CONTACT—C. J. Beckwith, Los Angeles, Calif., HO 6-3266.

**MELPAR, INC.,** 3000 Arlington Blvd., Falls Church, Va.

• SPECIALTIES—Automatic checkout equipment; trainers and simulators for fixed and rotary wing aircraft and air to ground missiles.

• CONTRACTS—Trainer for GAM-83 missile, flight line and bench check out systems for An/ALD-4 Reconaissance Systems; classroom trainer for instructing ASW crews of HSS-2 helicopter.

• CONTACT—R. E. Miller, V-P, Engrg. Services, JE 4-6000 Ext. 2422.

**MERIDIAN METALCRAFT, INC.,** 8739 S. Millergrove Dr., Whittier, Calif.

• SPECIALTIES — Complex special purpose waveguide assemblies and components for automatic flight line checkout for airborne fire control and mapping radars and navigation radar test sets.

• CONTRACTS—Microwave part of pulse radar test set for Remanco, Inc., precision multiple microwave attenuators for Ryan Electronics, L-band confidence test antennas for Hoffman Electronics.

• CONTACT—W. G. Sterns, V-P, Engineering.

**MICRO GEE PRODUCTS, INC.,** 6319 W. Slauson Ave., Culver City, Calif.

• SPECIALTIES — Servo controlled test equipment for static and dynamic evaluation of devices such as gyros accelerometers and complete inertial packages.

• CONTRACTS — Three-axis flight simulation table for NASA; dual two axis missile target simulator for Red Eye missile control system; gyro test equipment for Polaris instrumentation and flight control packages.

• LITERATURE—Checkout Equipment Catalog (No. **1313** on Card).

• CONTACT—R. W. Nowack, Mkt. Dir., EX 1-6719.

**MINNESOTA MINING & MANUFACTURING CO., MINCOM DIV.,** 2049 S. Barrington Ave., Los Angeles 25, Calif.

• SPECIALTIES — Magnetic instrumentation; analog and FM serial recorder-reproducers.

• CONTRACTS — Equipment for Polaris, Terrier, Pacific Missile Range data collection.

• LITERATURE — Predetection Recording (No. **1713** on Card). Phase Equalization (No. **1714** on Card). Hidden Data (No. **1715** on Card).

• CONTACT — C. S. Tobias, Div. Sales Mgr., BR 2-9971.

**MINNEAPOLIS-HONEYWELL REGULATOR CO., SPECIAL SYSTEMS DIV.,** Queen & Baily Sts., Pottstown, Pa.

• SPECIALTIES — Nuclear reactor simulator and control systems; missile propellant gas charging and cryogenic loading, sequencing simulation systems; penumatic pressure control systems for both high and low pressures and high and low temperatures; gas charging systems involving desgin, fabrication, installation and start-up; programming and distribution systems for cryogenic liquid transfer and control; hydrogen peroxide conditioned equipment for control of peroxide fuel loading and handling; electrical checkout systems for automatic monitoring of any variable; digital and analog control computers, magnetic tape units, and systems engineering for automatic checkout.

• CONTRACTS—Bomarc: complete gas charging control system; Atlas: pressurization control, pneumatic distribution, helium charge, and propellant transfer units; Saturn: electrical checkout and digital computer system.

• LITERATURE—Capabilities Study (No. **1314** on Card); Systems Support (No. **1315** on Card).

• CONTACT—A. L. Rogers, Mil. Sales Mgr., FA 3-4000.

**MISSILE COMPONENT CLEANING LABORATORIES DIV., QUAKER EXPORT PACKAGING CO.,** 2224 N. 10th St., Philadelphia 33, Pa.

• SPECIALTIES—Lox cleaning and testing tanks, storage vessels, valves, flexible hoses; on-site cleaning systems.

• CONTRACTS—Clean and test fuel and oxidizer storage vessels and propellant transfer components for Titan II; cleaning, cryogenic and control panels for Titan I.

• LITERATURE—Lox Cleaning Information (No. **1316** on Card). Ferroxyl Test Requirements (No. **1317** on Card); Vapor Phase-Acid Treatment (No. **1318** on Card).

• CONTACT—Leon Hertzson, Dir. of Eng., BA 9-0400.

**MISSILE SYSTEMS CORP.,** 9025 Wilshire Blvd., Beverly Hills, Calif.

• SPECIALTIES — Trailers, vans, electronic covoole cabinets, multi conductor cables/harness, umbilicals, personnel training devices for thermo nuclear bombardments; electro-mechanical devices such as missile launchers, bomb racks, bomb release mechanisms.

• CONTRACTS — Special weapon trainer for nuclear bomb training; test.

• LITERATURE—Missile Systems illustrated (No. **1319** on Card); Data Motion Facilities (No **1320** on Card); Multi-Conductor Harnesses (No. **1321** on Card).

• CONTACT—P. L. Kramer, V-P, Sales, CR 3-0510.

**MOBILE AERIAL TOWERS, INC.,** 1730 N. Harrison St., Ft. Wayne, Ind.

• SPECIALTIES—3-D precision controlled double-boom extensible personnel platforms for overhead operations.

• CONTRACTS — Pilot's capsule egress tower for Project Mercury; receiving antenna maintenance platform for Nike-Zeus; Missile base, missile maintenance, and tracking antenna maintenance platform for Jet Propulsion Laboratories.

• LITERATURE—Equipment Brochure (No **1322** on Card).

• CONTACT—W. F. Wessel, EAstbrook 4-624.

**MONSANTO CHEMICAL CO., AVIATION & SPECIAL FLUIDS DEPT.,** 800 N. Lindbergh, St. Louis 66, Mo.

• SPECIALTIES — Synthetic function fluids for fire resistant hydraulics for missile erection and launching systems, dielectric-coolant fluids for cooling of radar and communication systems, etc.

• LITERATURE—Skydrol Fire Resistant Hydraulic Fluids (No. **1695** on Card). Coolanol Dielectric-Coolant Fluids (No. **1696** on Card). Arockor Dielectric Fluids (No. **1697** on Card).

**MOTOR GENERATOR CORP.,** W. Water St., Troy, Ohio

• SPECIALTIES—Precision DC and 400 cycle AC power generation system; trailer, truck mounted and self-propelled units with electric, gas or diesel prime movers with ratings from 3.75 KVA to 140 KVA.

• CONTRACTS—Units for MACE, Dew Line Radar, and Pershing system test power.

• LITERATURE — Electrical GSE Catalog (No. **1323** on Card); 400 Cycle Product Brochure (No. **1324** on Card); DC Product Brochure (No. **1325** on Card).

• CONTACT—J. A. Guild, Sales Mgr., FE 2-1223.

**GEORGE L. NANKERVIS CO.,** 15300 Fullerton Ave., Detroit 27, Mich.

• SPECIALTIES—Hydraulic micro filtration systems.

• CONTRACTS—Hydraulic filtration tactical support units for Hawk.

• LITERATURE—Missile Test and Support Equipment (No. **1326** on Card); Hydraulic Filtration Cart (No. **1327** on Card). Hydraulic Components Test Stand (No. **1328** on Card).

• CONTACT—Eugene Madden, Sales Mgr.-GSE, VE 8-5780.

**THE NATIONAL CASH REGISTER CO., ELECTRONICS DIV.,** 1401 East El Segundo Blvd., Hawthorne, Calif.

• SPECIALTIES — Light reversible photochromic film display systems for applications requiring real time dynamic X-Y plotting and/or alphanumeric writing presentations for control monitoring, tactical plotters, trainers and simulators.

• CONTRACTS—Mark 20 plotter display for BuWeps.

• LITERATURE — Photochromic Dynamic Display Data Sheet (No. **1329** on Card).

• CONTACT—L. J. Hines, Mgr., Mil. Dept., OS 9-3671, Ext. 13, 14.

**NAVIGATION COMPUTER CORP.,** Valley Forge Industrial Park, Norristown, Pa.

• SPECIALTIES—Transistorized dig-

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• CONTRACTS — Plug-in digital modules for Advent ground checkout; solid state modules for Skybolt ground checkout.

• LITERATURE—Modules Catalog (No. **1330** on Card). Systems Brochure (No. **1331** on Card).

• CONTACT—D. M. Biberman, V-P, Sales, GL 2-6531, Ext. 35.

**NELSON ELECTRIC MANUFACTURING CO.,** Box 5385, Tulsa, Okla.

• SPECIALTIES — Ground power switchgear, motor controls, control systems and consoles; launch monitoring unction boxes for fuel; transistorized power supplies and explosion-proof aluminum cast enclosures.

• CONTRACTS — Explosion-proof aluminum control boxes (including circuitry) for Thor fueling system; water and dust-tight aluminum junction boxes (completely wired) for Titan GSE.

• LITERATURE — GSE Literature (No. **1332** on Card); Electronic Brochure (No. **1333** on Card).

• CONTACT—John McKeown, NA 7-5530.

**NEWAY EQUIPMENT CO.,** 1183 E. Laketon Ave., Muskegon, Mich.

• SPECIALTIES — Suspension systems with exacting ride characteristics.

• CONTRACTS—Trailer transport. Tandem air suspension for Minuteman.

• LITERATURE—Air Suspensions No. **1334** on Card); Tandem Suspensions (No. **1335** on Card); RTS Trailer Suspensions (No. **1336** on Card).

• CONTACT—M. F. Feather, Sales Mgr., PA 2-7667.

**NON-LINEAR SYSTEMS, INC.,** Del Mar Airport, Del Mar, Calif.

• SPECIALTIES—Digital voltmeters and ohmeters; high speed analog-to-digital converters; digital and analog go•no go comparators; data logging systems.

• LITERATURE—General Catalog (No. **1337** on Card).

• CONTACT—Herbert Tragesser, SK 5-1134.

**NORMANDY ELECTRIC WIRE CORP.,** 125 2nd St., Brooklyn 31, N. Y.

• SPECIALTIES—Insulated electric wire and cable including Mil-C-2194D, Mil-C-915A amendment 8, and Mil-C-17A.

• CONTRACTS—Electric wire and cable for Polaris, Aerojet-General, and Chance-Vought.

• LITERATURE — Cable Catalog (No. **1338** on Card).

• CONTACT—L. W. Goody, V-P for Mrktng., TR 5-9863.

**NORTH ATLANTIC INDUSTRIES, INC.,** Terminal Dr., Plainview, N. Y.

• SPECIALTIES—Ratiometric and absolute precision AC measurements; manufactures a line of precision AC Ratio Bases, Phase Angle Voltmeters, Complex Voltage Ratiometers and Phase Sensitive AC to DC Converters.

• CONTRACTS—Ratio test set for ground alignment of Atlas guidance system; computer alignment test set for Talos; gyro and resolver tester for Kearfott.

• LITERATURE—Complex Voltage Ratiometer Data Sheet (No. **1339** on Card); Solid State Phase AngleVoltmeter (No. **1340** on Card). Phase Sensitive Converter (No. **1341** on Card).

• CONTACT—Phil Greenstein, Instrument Sales Mgr., OV 1-8600.

**NORTH HILLS ELECTRONICS, INC.,** Alexander Place, Glen Cove, N.Y.

• SPECIALTIES — Ultra-precision power sources for calibration of transducers, gyros, etc.

• CONTRACTS — Ultra-precision power source for transducer calibration (Minuteman).

• LITERATURE — Precision Current Sources (No. **1694** on Cards).

• CONTACT—Sydney Cramer, Sales Mgr., OR 1-5700.

**NORTHROP CORP., NORAIR DIV.,** 1001 E. Broadway, Hawthorne, Calif.

• SPECIALTIES — Site construction and pad facilities; ground handling storage and transport; launchers and erectors; automatic checkout; trainers and test equipment; launch monitoring and control; launch and trajectory data acquisition; systems.

• CONTRACTS—Criteria, equipment, installation, and checkout SAC strategic missile base. Design criteria for ASD automatic test and checkout systems.

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• LITERATURE — Ground Support Systems: Brochure NB-60-23 (No. **1705** on Card). Range and Test Instrumentation: Brochure NB 60-334 (No. **1706** on Card). Site Activation and Engineering Services: Brochure NB 61-262 (No. **1707** on Card).

• CONTACT — L. H. Smith, Dir. Subcontracts, OS 5-4611 Ext. 747.

**NORTRONICS DIV., NORTHROP CORP., SYSTEMS SUPPORT DEPT.,** 500 E. Orangethorpe Ave., Anaheim, Calif.

• SPECIALTIES — Design, development and manufacture of opto-mechanical systems, automatic test systems, explosive ordnance/countermeasures, and mechanical ground support systems.

• CONTRACTS — Automatic test systems for Navy Polaris FBM system, 600-mm ballistic camera for USAF Atlantic Missile Range, Hawk launcher.

• LITERATURE—NSS-27 Automatic Test Systems (No. **1680** on Card). NSS-26 Ballistic Camera (No. **1681** on Card). NSS-16 Mechanical Support System (No. **1804** on Card).

• CONTACT — W. K. Vance, Dir., Appl. Engr.

**NUCLEDYNE DIV., COOK ELECTRIC CO.,** 3412 River Rd., Franklin Park, Ill.

• SPECIALTIES — Environmental test chambers for simulating extreme altitude, solar heating, cold void exposure and vibration, either singly or in combination; static thrust stands for rocket motor test firings; high-low temperature roadable field conditioning carts; dry ice to liquid $CO_2$ conversion units for use in recharging fire extinguisher units special metal shipping containers.

• CONTRACTS — "Dynamic analyzer" space environment chamber for Air Force; Ultra-high vacuum chamber for NASA; $CO_2$ conversion units for Air Force.

• LITERATURE—Capabilities Booklet (No. **1342** on Card); Company Brochure (No. **1343** on Card).

• CONTACT—J. H. Moeller, Staff Asst. to Gen. Mgr. 678-0990.

**OMNITRONICS INC.,** 511 N. Brant St., Philadelphia, Pa.

• SPECIALTIES — Input-output programing; data acquisition equipment; paper tape reading and recording.

• CONTRACTS — GE MSVD, Thompson Ramo Woolridge transistor computer (tape program).

• LITERATURE—PTR-7 Photoelectric Tape Reader (No. **1682** on Card). EPR-7 Coded Tape Recorder (No. **1683** on Card). RS-200 Paper Tape Reeler (No. **1684** on Card).

• CONTACT — Art Fitzpatrick, WA 5-4343.

**ON MARK COUPLINGS, INC.,** 4440 York Blvd., Los Angeles 41, Calif.

• SPECIALTIES—Quick disconnect applications for cryogenic, nuclear and exotic fuel apparatus; long-term storage and handling disconnects; manipulator and explosive operated connectors; specialized mechanical disconnects and flexible connections for extreme vibration applications extreme low temperature and high temperature applications where leakage or spillage could create hazards; venting and cooling applications where hardware is supported directly by vehicle during storage, run-up, or fly-away.

• CONTRACTS—Venting system for Titan I Lox boil off; units for Atlas F


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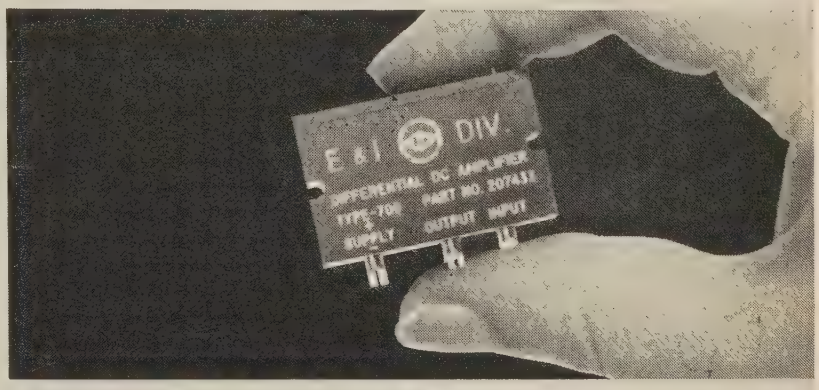


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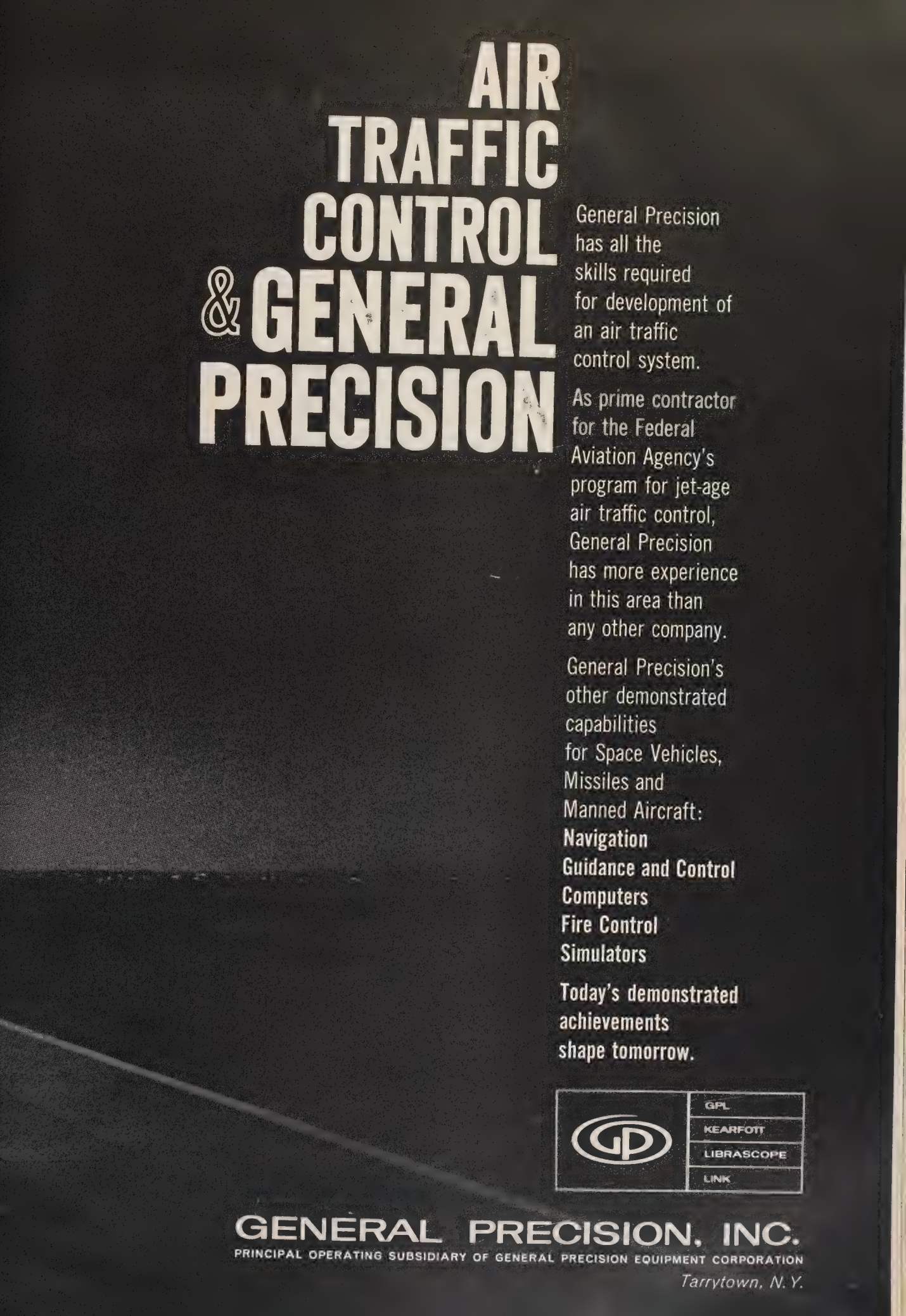
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• CONTACT—J. A. Stephens, Contracts Mgr., CL 4-2501.

**OPTIMIZED DEVICES, INC.,** 864 Franklin Ave., Thornwood, N. Y.
• SPECIALTIES—Automatic electronic test equipment.
• CONTACT—A. Zuch, Pres., RO 9-6110.

**OPTOMECHANISMS INC.,** Engineers Hill, Plainview, N. Y.
• SPECIALTIES — Optical tracking; infrared; photogrammetric, photometric and photographic instrumentation.
• CONTRACTS—Sky photometer for Signal Corps to measure, integrate, and record sky illumination; satellite and missile monitoring system for Air Force; rapid film processor system and display for G.E.
• LITERATURE — 70-mm Stereo Viewer (No. **1344** on Card); Monitoring System (No. **1345** on Card); Sky Photometer (No. **1346** on Card).
• CONTACT—Anwar Chitayat, V-P, Engineering, PI 6-5576.

**OPW-JORDAN DIV., DOVER CORP.,** 6013 Wiehe Rd., Cincinnati 37, Ohio.
• SPECIALTIES — Control valves, pressure regulators, temperature regulators, quick couplings, fuel handling and storage specialty valves, liquid loaders, line strainers, differential regulators, back pressure regulators.
• LITERATURE — Control Valves (No. **1347** on Card). Temperature Regulators (No. **1348** on Card). Pressure Regulators (No. **1349** on Card).
• CONTACT—N. J. Kraus, Regional Sales Mgr., El 1-1352.

**OTIS ELEVATOR CO., DEFENSE & INDUSTRIAL DIV.,** 35 Ryerson St., Brooklyn 5, N. Y.
• SPECIALTIES—Electronic countdown and checkout equipment.
• CONTRACTS—Atlas, Polaris, and Jupiter.
• LITERATURE—Interests and Skills Brochure (No. **1350** on Card).
• CONTACT—W. G. Bain, Mgr., Cust. Relations, UL 5-6800.

**PACIFIC AUTOMATION PRODUCTS, INC.,** 1200 Air Way, Glendale 1, Calif.
• SPECIALTIES—Vans, trailers & Shelters: electrical/electronic missile checkout, Communication and Data Acquisition Systems Trailers; universal automatic control and test equipment (UACTE) tape-programed; telemetry voltage calibration equipment auto-programmed and manual; precision voltage calibration.
• CONTRACTS—Telemetry voltage calibration equipment for Minuteman; 5 mc pre-detection recording system for Samos/Midas, van mounted communications station for Discoverer.
• LITERATURE—Universal Automatic Control and Test Equipment (No. **1351** on Card); Telemetry Calibration set (No. **1352** on Card). 5 MC Pre-Detection Recording System (No. **1353** on Card).
• CONTACT—D. R. Kerr, Mgr., Systems Engineering, CI 6-2411 Ext. 311.

**PACIFIC COAST ENGINEERING CO.,** Drawer E, Alameda, Calif.
• SPECIALTIES—Custom designers and fabricators of heavy equipment; missile site cranes to 60 tons; hoists and trucks (on which tower moves); hydraulic rams for lifting towers to trucks; tower propulsion and propulsion control.
• CONTRACTS—Subcontractor for Saturn tower.
• CONTACT—Alex McClure, Gen. Sales Mgr., LA 2-6100.

**PACIFIC DIV., HOUSTON FEARLESS CORP.,** 24660 Crenshaw Blvd., Torrance, Calif.
• SPECIALTIES—Ground servicing units for ground, airborne and space vehicles including ammonia trailers, cooling units, training and test simulators; missile booster fuel transfer systems as well as test stands.
• CONTRACTS—Ammonia servicing trailers for Hound Dog; major subcontractor test stands for Ranger; controlled environment to test transponders for Atlas.
• LITERATURE—Company Capability Brochure (No. **1354** on Card). Project Data Sheets (No. 1355 on Card).
• CONTACT—David Miller, Dir. of Engineering, DA 6-0733 Ext. 31.

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**PACIFIC VALVES, INC.,** 3201 Walnut Ave., Long Beach 7, Calif.

- SPECIALTIES — Cryogenic gate valves, straight and Y-pattern globe valves, ball valves, swing check valves, and lift check valves; jacketed valves for ultra low temperatures, for low and high pressures; high pressure gas regulators to 10,000 psig; balanced globe valves to 6,000 psig; check valves to 6,000 psig; corrosion resistant valves; valve designs for critical services.
- CONTRACTS—Cryogenic globe valves for Saturn; test stand gate valves for UDMH and $N_2O_4$ for Titan II; test stand high and low pressure globe valves for Titan II.
- LITERATURE—High Pressure Balanced Globe Valves (No. **1356** on Card). Cryogenic and Ball Valve Catalogs (No. **1357** on Card). Corrosion Resistant Service Valves.
- CONTACT—R. J. Dumm, Spec. Prod. Div., GA 6-2531.

**PACKARD BELL COMPUTER CORP.,** 1905 Armacost Ave., Los Angeles 25, Calif.

- SPECIALTIES — Digital control computers and systems; data acquisition, control, and checkout equipment.
- CONTRACTS—Automatic checkout for Saturn; data acquisition for Transit.
- LITERATURE—System Evaluator (No. **1358** on Card); Peripheral Equipment (No. **1359** on Card); PB250 Computer (No. **1360** on Card).
- CONTACT—T. J. Smith, Dir. of Mktng.

**PACKARD - BELL ELECTRONICS CORP.,** 12333 West Olympic Blvd., Los Angeles 64, Calif.

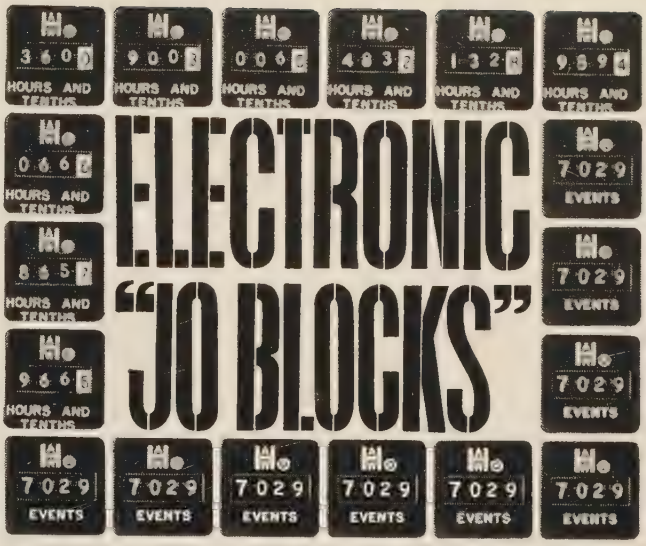
- CONTRACTS—Automatic system evaluator for Saturn; test equipment for Talos and Skybolt.
- LITERATURE—Ground Support Equipment (No. **1361** on Card). System Evaluator (No. **1362** on Card). Research and Development Capability (No. **1363** on Card).
- CONTACT—H. L. Vick, Dir. of Mktng, BR 2-6141 Ext. 216.

**PAGE COMMUNICATIONS ENGINEERS, INC.,** 2001 Wisconsin Ave., N.W., Washington 7, D.C.

- SPECIALTIES—Ground communications systems, communications networks.
- CONTRACTS — Feasibility communications studies for AF space surveillance systems; Pacific Missile Range communications survey for Navy.
- LITERATURE — Capability Brochure (No. **1679** on Card).
- CONTACT—F. W. Donkin, Sr. V-P, Mktg.

**PAN AMERICAN WORLD AIRWAYS, INC., GUIDED MISSILES RANGE DIV.,** Box 4187, Patrick AFB, Fla.

- SPECIALTIES—Missile range service and operations long range advance site planning; pre-launch planning in instrumentation support, telemetry engineering, pulse radar and infra-red tracking; countdown monitoring; fueling and propellant handling; fire and medical standby, pad safety, food service, pad engineering; nose cone recovery, weather gathering and evaluation, and maintenance; data acquisition and reduction. gistical support, maintenance, range de-
- CONTRACTS—Administration, lo-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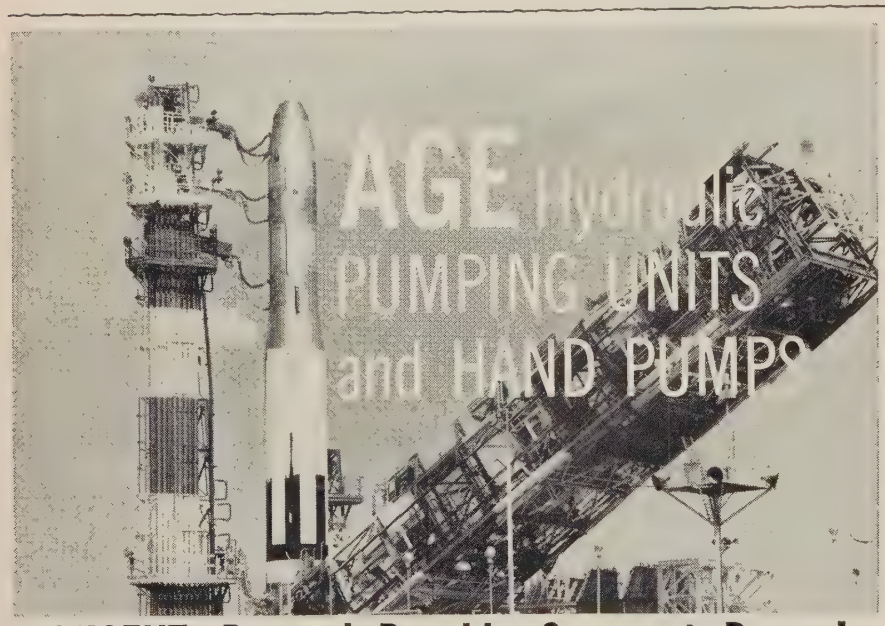
• CONTACT—J. F. Fortes, Public Rel. Rep.

**THE RALPH M. PARSONS CO.,** 617 West 7th St., Los Angeles 17, Calif.

• SPECIALTIES—Development of criteria, plans and specifications and construction or construction supervision of: silo launch bases, missile test and launch facilities, satellite launch and tracking facilities, liquid hydrogen engine test facilities, solid propellant manufacturing plants; development and manufacture of Miss Indicators, ground and airborne telemetry equipment, and precision electronic timing devices.

• CONTRACTS—Titan silo launch test facility at Vandenberg AFB; Titan training facilities at Sheppard AFB and Chanute AFB; Titan operational readiness support trainer at Vandenberg AFB.

• LITERATURE—Look to Parsons for Performance (No. **1364** on Card); Total Engineering and Construction Capability (No. **1365** on Card). Creative Electronics (No. **1366** on Card).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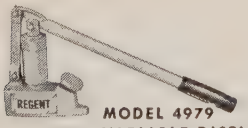
MODEL 5256 PORTABLE PUMPING UNIT. Adaptable to most requirements, designed for hard usage and minimum maintenance. Ball-type release valves for long life. Wear and corrosion resistant. Check ball valves in quick, replaceable cartridges. *Write for complete information on the Regent line.*

MODEL 5336 PORTABLE PUMPING UNIT. Versatile, simple unit available with ½" and 1" diameter pistons, O-ring packings and Teflon back-up rings for long life. Any combination of pump size and reservoir capacity available, from 80 cu. in. to 480 cu. in. *There's a Regent Pumping Unit for every requirement.*



MODEL 4979 VARIABLE DISPLACEMENT HAND PUMP. Advanced design and top efficiency with minimum weight. Automatic safety valve by-passes hydraulic fluid from pump to reservoir. Pressures up to 10,000 psi. Variable displacement, enables high speed, low-pressure; low speed, high pressure. *There's a Regent hand pump to meet your need!*

TO MEET YOUR SPECIFIC OPERATING AND PACKAGE REQUIREMENTS

| Model No. | Type | Piston Dia.-in. | Displacement per stroke cu. in. | Oil Capacity cu. in. | Max. Operating Pressure, psi. |
|---|---|---|---|---|---|
| 915-222 | Single acting | ½, 1 1/16, 1 | .25, .50, 1.0 | none | 10,000 |
| 915-BS | Double acting | ¾ | .625 | none | 3,000 |
| 4979 | Variable Displacement | ½, 1 | .25, 1.0 | none | 3,000 |
| 5256 | Single acting | 1 1/16 | .5 | 50 | 3,000 |
| 5020R | Single acting | ½ | .25 | 90 | 10,000 |
| 5016R | Single acting | 1 1/16 | .50 | 90 | 5,000 |
| 5219 | Single acting | ½, 1 1/16, 1 | .25, .50, 1.0 | 80, 190, 280, 410 | 10,000 |
| 5336 | 2-piston | ½, 1 | .25, 1.0 | 280 | 5,000 |

The leader in design and manufacture of pumps and pumping systems, Regent can engineer or adapt to your special requirements. Your inquiries are welcomed.

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REGENT JACK MANUFACTURING CO., INC.
11905 Regentview Avenue
Downey, California • SPruce 3-0103


• CONTACT—R. B. Dittmar, V-P, MA 9-2484.

**PAUL CHEMICAL CO., INC.,** 604 South Raymond Ave., Fullerton, Calif.

• SPECIALTIES — Cryogenic systems, rechargers, converters, vaporizers, high pressure pumps, super pressure pumps, and centrifugal pumps.

• CONTRACTS—Nuclear submarine support equipment; missile support for Redstone; shipboard subsystems.

• LITERATURE—Centrifugal Cryogenic Pumps (No. **1367** on Card); High Pressure Cryogenic Pumps (No. **1368** on Card); High Pressure Cryogenic Converters (No. **1369** on Card).

• CONTACT—P. P. Duron, Pres., TR 1-5454.

**PERKIN ELECTRONICS CORP.,** 345 Kansas St., El Segundo, Calif.

• SPECIALTIES—DC power supplies of low voltage (0-40 V) high current (0-1000 A) ratings.

• CONTRACTS — Transistor - regulated DC power supply for Titan I, II, Vanguard.

• LITERATURE—D. C. Power Supply Selection (No. **1370** on Card). Master Power Supply Chart (No. **1371** on Card); Power Supply Catalog (No. **1372** on Card).

• CONTACT—G. W. Mousel, Sales Mgr., EA 2-5320.

**PERKIN-ELMER CORP.,** Norwalk, Conn.

• SPECIALTIES — Azimuth alignment theodolites capable of detecting missile alignment deviations to less than a second of arc; recording optical tracking instruments (ROTO); film viewers; data analyzers; alignment periscopes and boresight cameras and autocollimators.

• CONTRACTS—Alignment theodolites to monitor azimuth heading for Atlas and Pershing; 2-axis flexure monitor system for Polaris; Optag (optical pick-off two-axis gyro) ultraminiature device for alignment monitoring of new advanced gyros.

• LITERATURE—Azimuth Alignment Theodolites (No. **1373** on Card); Long Range Optical Tracking Instruments (No. **1374** on Card); Flexure Monitor for Polaris Submarine (No. **1375** on Card).

• CONTACT—C. B. Hazzard, Jr., Dir. of Mktg., Electro-Optical Div., VI -0420.

**PERMANENT FILTER CORP.,** 18744 S. Reyes Ave., Compton, Calif.

• SPECIALTIES—Filters for fuels, oxidizers, gases and hydraulic oils over temperature ranges 2000°F to — 420°F; filter separators and dehydrators for jet fuels and RP fuels; complete self-propelled, trailer mounted and stationary filtration and separation systems.

• CONTRACTS—Dehydrator trailer for Titan; filtration cart for Chandler Evans.

• LITERATURE — Product Catalog (No. **1376** on Card). Perma Ray Catalog (No. **1377** on Card). Bulk Handling (No. **1378** on Card).

• CONTACT—Herbert Howard, Dir. of Mktng.



No. 241 on Reader Service Card

**PESCO PRODUCTS DIV., BORG WARNER CORP.,** 24700 N. Miles Rd., Bedford, Ohio

- SPECIALTIES—Liquid hydrogen, oxygen, and nitrogen pumps; environmental controls, axial flow fans, electronic cooling packages, thermo-electric cooling; hydraulics actuation and pumping equipment; electric motors and motor generator sets; static inverters; permanent magnet type rotating alternators.
- CONTRACTS—Motor generator set for Pershing; hydraulic power supply for Lacrosse; static inverter for Mace.
- LITERATURE—Progress Report on Cryogenics (No. **1379** on Card); Static Inverter Brochure :No. **1380** on Card); Environmental Control Brochure (No. **1381** on Card).
- CONTACT—R. L. Schroeder, Gen. Sales Mgr., AZ 2-6100.

**PHILCO CORP., GOVERNMENT & INDUSTRIAL GROUP,** 4700 Wissahickon Ave., Philadelphia 44, Pa.

- SPECIALTIES — All phases of tracking, command, control, telemetry and communications.
- CONTRACTS — Command and control systems for Discoverer; command and control system, tracking, telemetering for Advent; command and control for Midas.
- CONTACT — E. F. Canfield, Mktng. Mgr., 758-2344.

**PHILCO CORP., GOVERNMENT & INDUSTRIAL GROUP, COMMUNICATIONS & WEAPONS DIV.,** 4700 Wissahickon Ave., Philadelphia 44, Pa.

- SPECIALTIES—Field engineering and ground support for ground and airborne radar, missile guidance, control, and fuzing systems; microwave, scatter, and global communications; data links; high-speed switching; advanced communications; satellite tracking, command and control; and systems management.
- CONTRACTS—Equipment for Discoverer-Midas series, and defense communications agency.
- CONTACT — Conrad Young, Mktng. Mgr., 758-5000.

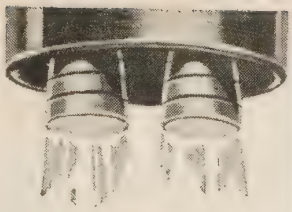
**PHILCO CORP., GOVERNMENT & INDUSTRIAL GROUP, COMMUNICATIONS SYSTEMS DIV.,** 515 Pennsylvania Ave., Ft. Washington, Pa.

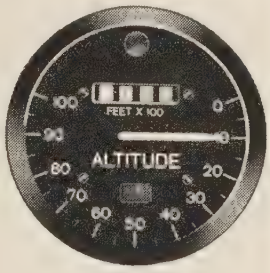
- SPECIALTIES — Design and installation of communications and display systems; global communications systems.
- CONTACT — Mathew Kerbec, Mktng. Mgr., MI 6-8600.

**PHILCO CORP., GOVERNMENT & INDUSTRIAL GROUP, COMPUTER DIV.,** 3900 Welsh Rd., Willow Grove, Pa.

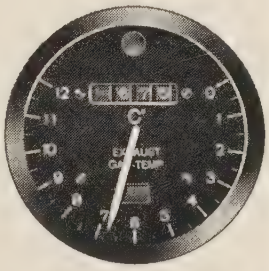
- SPECIALTIES — General-purpose large-scale electronic data processing systems; control computers; mobile military computers.
- CONTRACTS—Spadats.
- CONTACT—J. M. Hertzberg, V-P, Mktng., OL 9-7700.

**PHILCO CORP., GOVERNMENT & INDUSTRIAL GROUP, SIERRA ELECTRONIC DIV.,** 3885 Bohannon Dr., Menlo Park, Calif.






ALTITUDE

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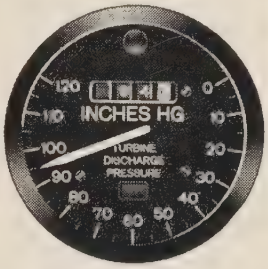
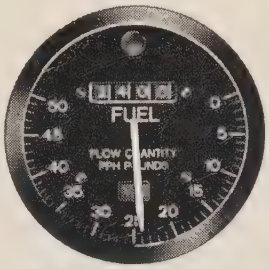
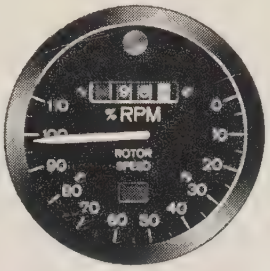



TURBINE PRESSURE




FUEL FLOW & QUANTITY

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• SPECIALTIES — Testing equipment, remote control monitoring systems, high powered transmitters, and telemetry systems.
• CONTACT — Charles Volkland, Mktg. Mgr., DA 6-2060.

**PHILCO CORP., GOVERNMENT & INDUSTRIAL GROUP, WESTERN DEVELOPMENT LABORATORIES,** 3875 Fabian Way, Palo Alto, Calif.
• SPECIALTIES—Space instrumentation; satellite tracking, command and communications; systems analysis; space communications; satellite telemetry and data antennas.
• CONTRACTS — Discoverer-Midas series, Courier.
• CONTACT—G. C. Trotter, Mktg. Mgr., DA 6-4350.

**PHILCO CORP., TECHREP DIV.,** C & Westmoreland Sts., Philadelphia, Pa.
• SPECIALTIES—Site equipment installation, maintenance, and training; site preparation, buildings and roads; man in space monitoring.
• CONTRACTS—Mercury.
• CONTACT—Frank Creaser, Sales Mgr., 443-2000.

**PIASECKI AIRCRAFT CORP.,** Island Road, Philadelphia 42, Pa.
• SPECIALTIES — Hydraulic and pneumatic actuated mating carriages, lifting devices and handling cradles; self power-roadable ground handling and mating trucks and dollies; shelters, consoles, cabinets and electronic equipment for both reception and transmission of data and control; structural and mechanical components for space environment simulators; electronic recording and control panels.
• CONTRACTS—Mating devices for SkyBolt, Mark 6 prototype and prime transport and mating equipment; prototype and prime support equipment for Samos II.
• LITERATURE—Systems and subsystems (No. **1382** on Card).
• CONTACT—J. A. Nacchio, Sales Liaison Eng., SA 4-2222.

**PNEU-HYDRO VALVE CORP.,** 52 Horse Hill Rd., Cedar Knolls, N.J.
• SPECIALTIES — Pneumatic and hydraulic systems and control components.
• CONTRACTS—3-inch check valve for Titan II hydrazine unit; thermal control valve for Polaris inertial guidance system shipping container; 5 inch ball valve for NASA wind tunnel.
• LITERATURE — Brochure (No. **1383** on Card). Sales Drawings (No. **1384** on Card). Facility Report (No. **1385 on** Card).
• CONTACT—J. W. Reilly, Sales Mgr., JE 8-7200.

**POLARAD ELECTRONICS CORP.,** 43-20 34th St., Long Island City 1, N. Y.
• SPECIALTIES—Microwave test equipment; automatic preflight checkout systems; command and beacon test sets; transponder and missile angle tracker calibration units; rocket programmer checkout systems, and similar ground support equipments.
• CONTRACTS—Automatically programmed FM signal generator for Bomarc B; automatic signal generators and receivers for B-58; checkout equipment for Firebee Drone.
• LITERATURE—Missile GSE Facilities survey (No. **1386** on Card). Microwave Electronic Test Equipment (No. **1387** on Card); Notes on Microwave Measurements (No. **1388** on Card).
• CONTACT—Harry Zimmerman, EX 2-4500 Ext. 381.

**PORTLAND COPPER & TANK WORKS, INC.,** 80 Second St., South Portland, Me.
• SPECIALTIES—Ground handling storage and transport cabinets, consoles, control panels; storage pallets, vans, trailers, and shelters; cryogenics handling, storage tanks, handling hoods, casks, in-pile loops.
• CONTRACTS—Storage and transport pallets for Hawk; antennae, klystron tubes and back-up structures for Dew line and down range programs; han-


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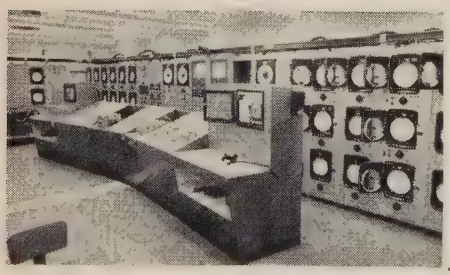
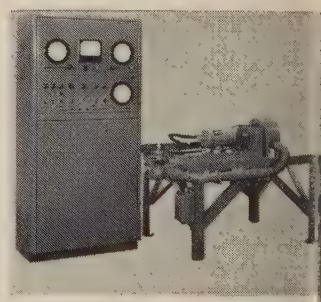
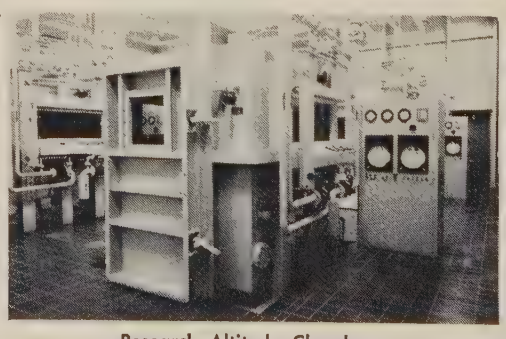


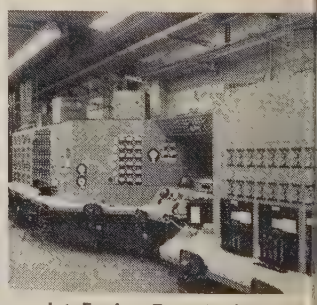
Rocket Engine Test Facility



Air Turbine Starter Test Stand



Research Altitude Chamber



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EMerson 8-3566

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P.O. Box 35-125
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PLaza 1-0293

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EXecutive 3-5350

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dling hoods, storage tanks, disposal casks, in-pile loops for GE atomic power-plants.

• LITERATURE — Facilities (No. **1389** on Card). Product Data Lists (No. **1390** on Card). Brochures (No. **1391** on Card).

• CONTACT—F. D. Hugo, Dir. of Sales, SP 9-3341.

**THE WM. POWELL CO.,** 2525 Spring Grove Ave., Cincinnati 22, Ohio.

• SPECIALTIES—Bronze and stainless steel gate, globe, angle, check valves for handling liquid and gaseous helium, hydrogen, nitrogen, oxygen, etc.

• LITERATURE—Valves for Cryogenic and Allied Services (No. **1392** on Card).

• CONTACT—W. E. Heilig, V-P, DU 1-4699 Ext. 313.

**PRY WELDING & MANUFACTURING INC.,** Union St., Modena, Pa.

• SPECIALTIES—Re-usable metal containers for storage and handling fragile high unit value items requiring dunnage; large containers of Conex type; cargo bins; mobile carts, dollies, etc.

• CONTRACTS—Carrier and air field electronic cart for Navy; helicopter blade shipping and storage box for Army; torpedo shipping and storing container for Navy.

• LITERATURE—General Brochure (No. **1393** on Card). Equipment and Facilities List (No. **1394** on Card).

• CONTACT—E. C. MacBean, Pres., DU 4-8321.

**RADAR RELAY INC.,** 1631 10th St., Santa Monica, Calif.

• SPECIALTIES — Warning lights, control panels, annunciator systems, flasher units, and electronically controlled displays.

• CONTRACTS—Readout lights on Polaris submarines.

• LITERATURE—Product Brochure (No. **1395** on Card).

• CONTACT — W. C. Arrasmith, Pres., UP 0-8741.

**RADIATION INC.,** Melbourne, Fla.

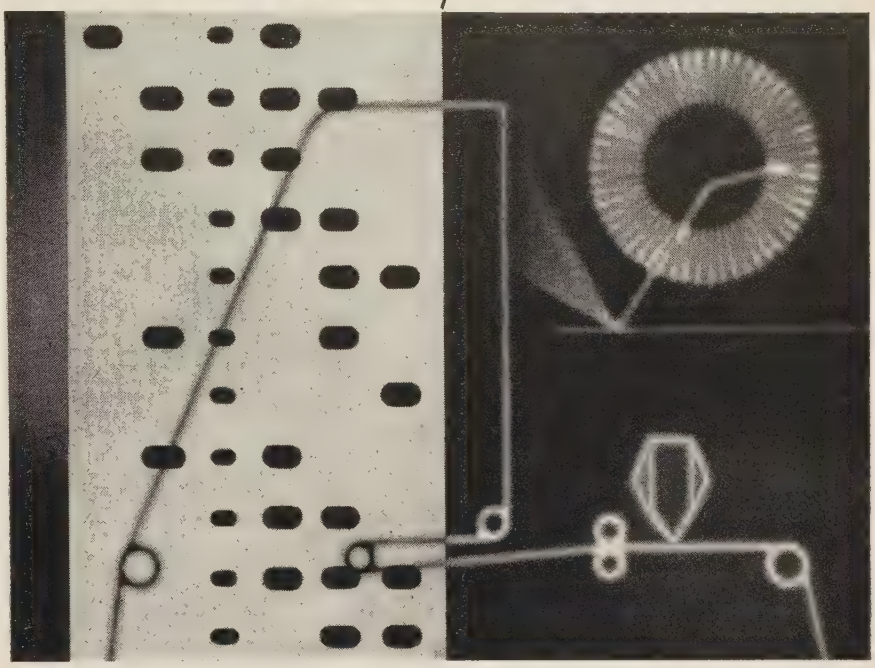
• SPECIALISTS—Antenna systems for acquiring information from missiles, space vehicles; automatic test equipment for testing electronic circuits, components and systems for aircraft and missiles; missile-firing operations simulators; data systems for use in large simulation systems; complete PCM data acquisition, editing, processing systems for telemetered information from static and airborne sources; digital/analog systems, tape and buffer systems, etc.

• CONTRACTS—Data acquisition a processing system for Nimbus weather satellite information; antenna system for Dynasoar manned orbital glider program; tape and buffer systems, data processing for Nike-Zeus anti-missile missile system.

• LITERATURE—Automatic Test Equipment Brochure (No. **1576** on Card); Proven Capabilities in PCM Telemetry Systems (No. **1577** on Card); Digital Techniques in Airborne Data Acquisition (No. **1578** on Card).

• CONTACT—Dir. of Mktg., PA 3-1511.

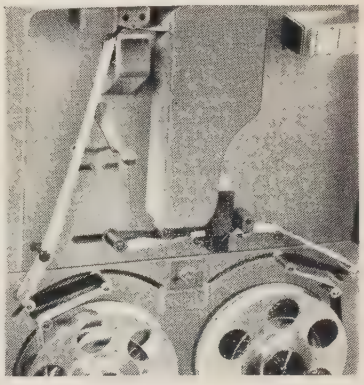

# omni-data ...a new generation in paper-tape equipment



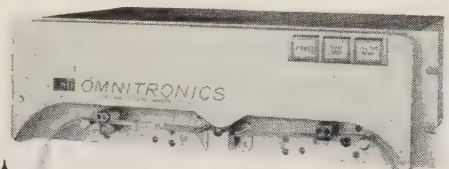
- **High-speed electrostatic paper-tape recorder replaces mechanical punches**
- **Reflected-light reader accommodates all tapes—punched or recorded, opaque or transparent**

OMNI-DATA, a new line of equipment based on non-mechanical, non-impact reading and recording techniques, brings a new order of reliability, speed, and operating life to the application of coded paper tape.

OMNI-DATA combines two exclusive Omnitronics advances: Visible recorded code presentation, rather than punched holes in the tape, and chopped-reflected-light reading, both resulting in new levels of performance and the elimination of the bothersome chads of punched tape.



Visible recorded data issues from OMNI-DATA recorder at speeds up to 600 characters a second at 10 characters to the inch. Even higher recording and reading speeds, as well as greater packing density, are possible.




Omnitronics Photoelectric Tape Reader, a part of the OMNI-DATA system, reads any kind of tape (OMNI-DATA or punched, opaque or transparent) interchangeably without adjustment.

*Learn the exciting details about OMNI-DATA recorders, readers, and reelers. Write for full information and the name of your nearest Omnitronics representative.*

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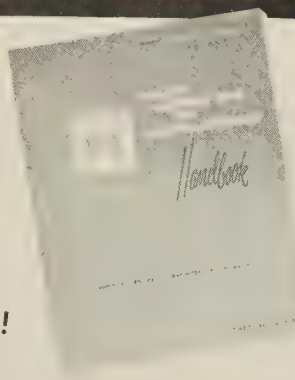

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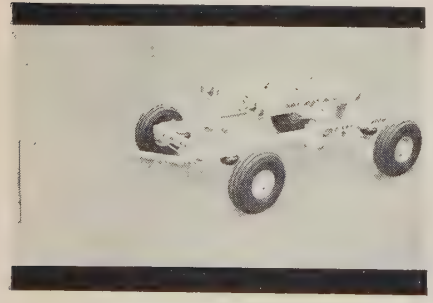

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**RADIO CORP. OF AMERICA, ASTRO-ELECTRONICS DIV.,** Princeton, N. J.

• SPECIALTIES—Space systems support equipment primarily for checkout, command, control and receiving; information reduction for satellites and space vehicles.

• CONTRACTS — Checkout, command & program, and pictorial and telemetry data receiving station equipment for Tiros.

• LITERATURE—Capabilities and Facilities (No. **1396** on Card). Imagery Simulation and Enhancement Techniques (No. **1397** on Card).

• CONTACT—M. G. Staton, Mgr., Mkt. Devel., WA 4-2700.

**RADIO CORP. OF AMERICA, Systems Support,** Camden, N. J.

• SPECIALTIES—Digital evaluation equipment (integrated family of general-purpose building blocks, can be assembled into any desired test system). DATS for rapid go-no-go checkout. APCHE for automatic, programed large-booster pre-launch checkout. Life sciences. Advanced maintenance techniques. Space chamber instrumentation. Teaching machines. Simulators and trainers. Specialized test systems of all types.

• CONTRACTS — Computer - controlled DEE for the Signal Corps. APATS for Lockheed for automatic testing of space vehicles. DATS for preflight F-102 fire control system.

• LITERATURE—DEE (No. **1685** on Card). DATS (No. **1686** on Card). Life Sciences (No. **1687** on Card).

• CONTACT—Dobson, WO 3-8000 Ext. PC-3968.

**RADIOPLANE DIV., NORTHROP CORP.,** 8000 Woodley Ave., Van Nuys, Calif.

• SPECIALTIES—Automatic and semi-automatic combined systems test sets; ground-based data processing equipment; launchers including zero length designs; trainers and test simulators.

• CONTRACTS — XQ-4B ground support equipment for the Air Force; SD-1 and RP-76 equipment for the Army.

• LITERATURE—Ground Support Equipment Brochure (No. **1398** on Card).

• CONTACT—D. Welch, Proj. Eng., Controls & Communications Group, ST 6-7020 Ext. 257.

**RAYTHEON CO., SURFACE RADAR & NAVIGATION OPERATION,** Boston Post Rd., Wayland, Mass.

• SPECIALTIES — Missile battery control centers and mobile weather radar systems; automatic checkout fault location performance monitors; sonar and fire control radar trainers and simulators; module testers; target analyzer computer; displays.

• CONTRACTS — Interconnections engineering for Hawk; radar module tester for Tartar; performance monitor for FAA.

• LITERATURE — GSE Brochure (No. **1399** on Card); Module Tester Brochure (No. **1400** on Card). Capabilities Brochure (No. **1401** on Card).

• CONTACT—Mktg. Mgr., EL 8-2721.

**REEVES INSTRUMENT CORP.,** Garden City, N. Y.

• SPECIALTIES—Precision instrumentation radar for angle tracking, range safety, guidance, trajectory measurement and control; two and three axis antenna pedestals; adaptation of radars to airborne van mounting; special and general purpose analog computers; electronic function generators and multipliers; gyro and resolver test equipment; radar depot test equipment.

• CONTRACTS—Three axis pedestals for Discoverer, Midas & Samos; very long range acquisition and angle tracking radars for Discoverer & Mercury; radar drone control for Navy.

• LITERATURE—Analog Computer Handbook (No. **1402** on Card); Pedestal Brochure (No. **1403** on Card); Test Equipment Brochures (No. **1404** on Card).

• CONTACT—Paul Andrepont, Mil. Sys. Dir., PI 6-8100.

**REFLECTONE ELECTRONICS INC.,** Stamford, Conn.

• SPECIALTIES — Complex electronic trainers and simulators for training aircrew members, astronauts, submarine crews; electronic countermeasures trainers and simulators, navigational trainers; fire control simulators; advanced research on aero space environmental, operational simulators for spacecraft, orbital vehicles.

• CONTRACTS — Defense system officer ECM simulator for B-58; B-52 ECM simulator.

• LITERATURE—Training Devices Cut Cost and Time (No. **1579** on Card); A Low Cost B-58 Defense System Simulator (No. **1580** on Card).

• CONTACT—John Thaler, DA 5-2251.

**REGENT JACK MFG. CO., INC.,** 11905 Regentview Ave., Downey, Calif.

• SPECIALTIES—Hydraulic quick lowering, mechanical locking self-retracting leveling jacks; automatic mechanical locking cylinders; hydraulic test cylinders and jacks; trailers and dollies.

• CONTRACTS — Ratchet lock hydraulic cylinders for Genie; leveling jacks for Polaris; 100-150 ton hydro-mechanical jacks for Titan I silo.

• LITERATURE — GSE Brochure (No. **1405** on Card); Hydro-mechanical Actuators (No. **1406** on Card); Facilities Brochure (No. **1407** on Card).

• CONTACT—W. S. Noblett, V-P, SP 3-0103.

**REPUBLIC AVIATION CORP.,** Farmingdale, N. Y.

• SPECIALTIES — Battery service units, automatic chargers, testers, capacity analyzers, constant current dischargers, cell sensing and loading, automatic cycling for alkaline and acid type batteries; precision power units for supply and starting applications.

• CONTRACTS—Integrated battery support equipment for Air Force, NASA, Navy.

• LITERATURE—Complete Power and Support Package (No. **1408** on Card).

• CONTACT—A. B. Speed, Dir. of Sales, Spec. Prod. & Serv.

**REPUBLIC MANUFACTURING CO.,** 15655 Brookpark Rd., Cleveland 35, Ohio

• SPECIALTIES — Hydraulic and pneumatic components to handle high and low temperature gases or liquids with exceptionally low internal leakage.

• CONTRACTS—Control system for Saturn S1 transporter; hydraulic system

for Matador translauncher; emergency hydraulic system for Titan transporter.

• LITERATURE—General Catalog (No. **1409** on Card); Press-Ur-Seal Valves Bulletin (No. **1410** on Card); Hi-Shock Solenoid Valves Bulletin (No. **1411** on Card).

**RESDEL ENGINEERING CORP.,** 330 S. Fair Oaks Ave., Pasadena, Calif.

• SPECIALTIES — UHF Doppler ground receivers; semi-automatic ground checkout sets for missileborne transponders; data handling equipment.

• CONTRACTS—Transponder test set for Pershing; UHF phaselock Doppler receivers for Saturn; UHF low noise antenna amplifiers for Minuteman, Pershing, Saturn, Juno, Jupiter.

• LITERATURE—Low Noise Antenna Amplifiers, 100-1000 mc (No. **1412** on Card); Active Wide Band Multicoupler, 200-400 mc (No. **1413** on Card); Phaselock receiver (No. **1414** on Card).

• CONTACT—M. F. Brown, Jr., Asst. V-P, Eng., SY 5-5197.

**RESE ENGINEERING INC.,** A & Courtland Sts., Philadelphia 20, Pa.

• SPECIALTIES — Automatic test and checkout equipment for digital computers, processing systems, and high speed memories; computer simulators for memory test.

• CONTRACTS—2-microsecond automatic memory exercisers for Nike-Zeus; automatic test equipment for transfluxor matrix used in advanced Atlas guidance; coordinate conversion and antenna tracking guidance for Project Echo.

• LITERATURE—Facilities and Systems Brochure (No. **1415** on Card); Digital Logix Applications Handbook (No. **1416** on Card); Lore Memory Applications Handbook (No. **1417** on Card).

• CONTACT—A. N. Into, V-P, Mktg., GL 5-9000.

**RESISTOFLEX CORP.,** Roseland, N. J.

• SPECIALTIES—Teflon wire braided hose and hose assemblies, lined pipe, lined transfer hose, and molded Teflon bellows and expansion joints; fittings for field assembly with Teflon hose; high performance rigid tube fittings; heavy duty takedown joints for piping systems.

• CONTRACTS—Swaging equipment for Teflon hose manufacture for Saturn; transfer assemblies for propellant loading for Titan; teflon hose for oxygen service for Polaris.

• LITERATURE—New Aircraft Catalog (No. **1418** on Card); New Industrial Catalog (No. **1419** on Card); Product Data (No. **1420** on Card).

• CONTACT—Mrs. A. G. Pick, Asst. Sales Mgr., CA 6-7700.

**ROCKETDYNE DIV., NORTH AMERICAN AVIATION, INC.,** 6633 Canoga Ave., Canoga Park, Calif.

• SPECIALTIES—Liquid and solid propellant rocket engines control and monitor equipment for test and launch sites; mobile and stationary service equipment for conditioning and delivery of various cleaning, lubricating, preservative and purging fluids; checkout equipment featuring manual, remote and automatic control of electronic, electrical and fluid (including cryogenic) test circuits

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| **Lockbourne AFB** | Columbus, Ohio |
| **Loring AFB** | Limestone, Maine |
| **Lowry AFB** | Denver, Colorado |
| **National Aeronautical Space Administration** | Sandusky, Ohio |
| **Offutt AFB** | Omaha, Nebraska |
| **Plattsburg AFB** | Plattsburg, New York |
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for engine/vehicle systems and components checkout and handling equipment for transport, storage and handling of engine assemblies, including installation in missile/vehicle airframe.

• CONTRACTS—Complete support equipment system including control-monitor, service, checkout, and handling equipment for Atlas, Saturn, and NASA's 1.5 million-pound-thrust liquid rocket engine.

• LITERATURE—Propulsion Support Equipment Brochure (No. **1421** on Card); Vibration Safety Cutoff Brochure (No. **1422** on Card).

• CONTACT—H. W. Gilfillan, Chief, GSE Section, DI 7-5651 Ext. 2170.

**ROCKET POWER INC.,** Falcon Field, Mesa, Ariz.

• SPECIALTIES—Test of solid propellants; sled rockets for subsonic or supersonic tests; infrared emitters for missile targets and atmospheric calibration; jet and rocket engine starter cartridges; automatic fuel line disconnects for operation at rise-off; fluid and gas line disconnects; high pressure and temperature valves and seals; cable quick disconnects; hydraulic limiters.

• LITERATURE—Facilities booklet (No. **1581** on Card).

• CONTACT—P. F. Lambert, Plag. & Mktg., WO 4-1711.

**ROCKWELL STANDARD CORP., TRANSMISSION & AXLE DIV.,** 100-400 Clark Ave., Detroit 32, Mich.

• SPECIALTIES—Driving and non-driving single and tandem front axles; single speed and two-speed double-reduction rear axles; single-reduction, double-reduction and worm drive tandem rear axles; steering and rigid planetary axles; trailer axles; transfer cases; torque converters; power shift transmission; related components.

• LITERATURE—Tandem Driving Axles (No. **1423** on Card); Planetary Axles (No. **1424** on Card); Hydra Drives Transmission (No. **1425** on Card).

• CONTACT—J. M. Prange, Chief Mil. Eng., TA 6-6000.

**RONAN & KUNZL, INC.,** Marshall, Mich.

• SPECIALTIES—Skid, trailer and truck mounted cryogenic storage and transport equipment 50 gallon thru 2000 gallon capacities.

• CONTRACTS — Liquefied gas ground handling equipment for Lockheed; liquefied gas storage equipment for Martin; and liquefied gas storage and transport equipment for NASA.

• LITERATURE—More about Cryotainers (No. **1426** on Card); Cryotainer Storage and Transport (No. **1427 on** Card); Liquefied Gas Containers (No. **1428** on Card).

• CONTACT—R. K. Jeffers, Sales Mgr., ST 1-2861.

**RONSON HYDRAULIC UNITS CORP.,** 1313 Lincoln Ave., Pasadena, Calif.

• SPECIALTIES—Hydraulic power system studies for launch equipment including component valving and actuation.

• CONTRACTS — System relief valves for Minuteman; system relief valving for Atlas; lockout cylinders for Polaris.

• CONTACT — R. K. Boltz, V-P, Sales, MU 1-0221.

**THE RUCKER CO.,** 4700 San Pablo Ave., Oakland 8, Calif.

• SPECIALTIES—Development and installation of launcher-erector hydraulic control components and systems; mobile transporter hydraulic gear; missile hard site hydraulic actuators and controls; radio telescope drive systems; combined environmental simulation equipment; shock and stress simulation equipment.

• CONTRACTS—Silo door closers for Titan II; launcher erector hydraulic valves, manifolds, and accumulators for Bomarc; combined environmental simulation test facility for Edwards AFB.

• LITERATURE—Rucker Systems Brochure (No. **1429** on Card); Meet the Rucker Company (No. **1430** on Card); Rucker Centrifuge Acceleration Equipment (No. **1431** on Card).

• CONTACT—R. A. Cotter, Natl. Sys. Sales, OL 3-5221.

**RYAN INDUSTRIES, INC.,** 888 East


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• SPECIALTIES—Cryogenic equipment and portable handling equipment; storage equipment for liquid oxygen, argon, nitrogen and hydrogen in capacities from 30 gallons to 11,400 gallons; "permanent vacuums" for insulating; control systems.

• LITERATURE — Brochure (No. **1432** on Card).

• CONTACT—R. M. Haas, V-P, Eng. & Sales, UT 1-6878.

**SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP.,** 3900 Holland Rd., Saginaw, Mich.

• SPECIALTIES—Design and fabrication of ball bearing screws, ball bearing splines, and actuation systems for erectors, launchers, XY plotters, radar systems, etc.

• CONTRACTS—Ball bearing screws for Pershing erection and launch pad erection; rear leveling jacks and fifth wheel actuator for Minuteman Missile carrier; actuation system for erection of Scout rocket.

• LITERATURE—Design Data Book (No. **1433** on Card); Ready Reference Price List (No. **1434** on Card); The Actuator (No. **1435** on Card).

• CONTACT—P. V. Wysong, Jr., Chief Applications Eng., PL 4-9111.

**SANDERS ASSOCIATES, INC.,** 95 Canal St., Nashua, N. H.

• SPECIALTIES — Electronic and mechanical support equipment for quick reaction operational readiness; transmitter designs; electronic test equipment.

• LITERATURE—Plainview Brochure (No. **1436** on Card); Capabilities and Facilities (No. **1437** on Card).

• CONTACT—Frank Crook, Mgr., Elect. Sys. Mktg., TU 3-3321.

**SECURITY VALVE CO.,** 909 El Centro, South Pasadena, Calif.

• SPECIALTIES—Split, solid, and Y-body pattern valves from 150 lb. thru 2500 lb. and higher; temperature applications from minus 450 deg on liquid hydrogen service with vacuum jacketed valves to as high as 1800 deg for such service as hot helium; development of special valves up to 50,000 lb.

• CONTRACTS—Units for Edwards AFB static test missile stands; plasma wind tunnel for North American Aviation; cryogenic as well as high temperature valves for Brookhaven National Lab.

• LITERATURE—Missile Valve Bulletin (No. **1438** on Card).

• CONTACT—W. R. Kehoe, V-P of Sales, MU 2-3594.

**SERVOMECHANISMS, INC.,** 12500 Aviation Blvd., Hawthorne, Calif.

• SPECIALTIES—Lox tanking computers and propellant utilization systems for launch monitor and control Lox valve checkout equipment and automatic test sets; telemetry equipment.

• CONTRACTS—Lox tanking computer for Saturn; 30 channel multiplexer for Saturn; telemetry system for Army Rocketsonde.

• LITERATURE—Lox Tanking System (No. **1439** on Card); Thrust Control System (No. **1440** on Card); Propellant Utilization Control System (No. **1441** on Card).


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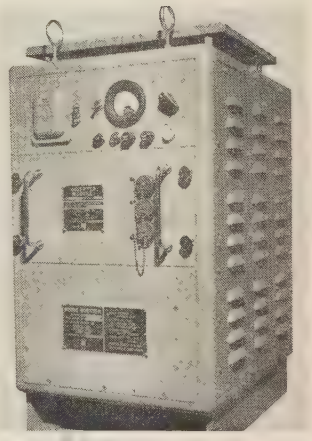

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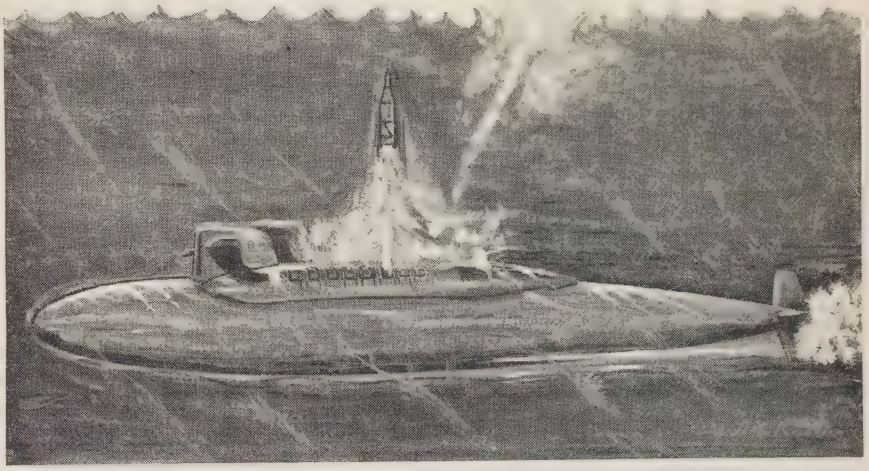

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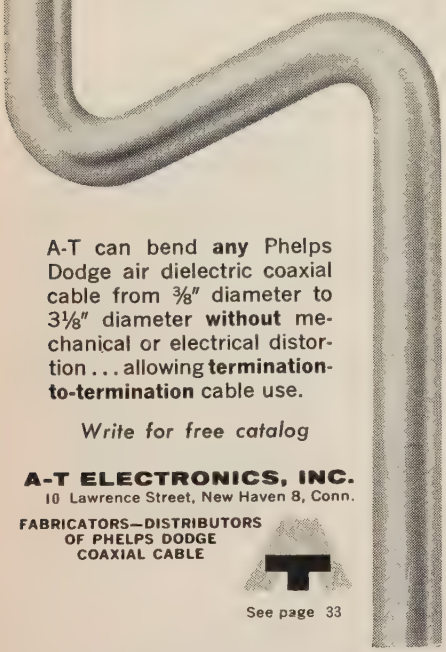

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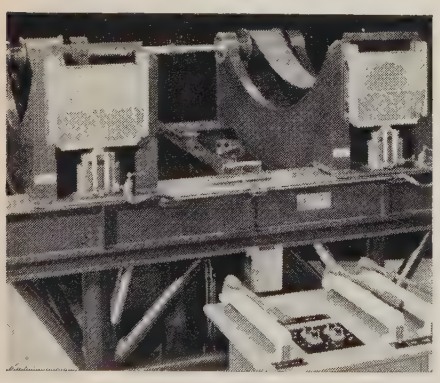

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• CONTACT—C. R. Zerkie, Sales Mgr., OR 8-7841.

**SILENT HOIST & CRANE CO.,** 841 63rd St., Brooklyn 20, N. Y.

• SPECIALTIES — Mobile cranes, fork lift truck, hoists and winches, straddle crane trucks, and heavy aircraft towing tractors.

• LITERATURE — Heavy Mobile cranes (No. **1442** on Card); Heavy-Duty Fork Lift Trucks (No. **1443** on Card); Towing Tractors (No. **1444** on Card).

• CONTACT—M. M. Botnick, V-P, BE 8-2525.

**SIMMONDS PRECISION PRODUCTS, INC.,** 105 White Plains Rd., Tarrytown, N.Y.

• SPECIALTIES—Cryogenic valves, push pull controls, latches.

• CONTRACTS—Push-pull control for Pershing hauler.

• LITERATURE—Push Pull Controls (No. **1445** on Card); Latches (No. **1446** on Card); Cryogenic Valves (No. **1447** on Card).

**SKYDYNE, INC.,** Box 1106, Port Jarvis, N. Y.

• SPECIALTIES—Shelters; consoles; instrument carrying cases and combination carrying and operation cases.

• CONTRACTS—Consoles for Hawk control systems; carrying cases for Dynasoar checkout equipments; equipment for Hamilton-Standard GSE Div.

• LITERATURE — Standard Case Catalogs (No. **1582** on Card); Standard Test Benches Data Sheet (No. **1583** on Card); Facilities Brochure (No. **1584** on Card).

• CONTACT—W. F. Maccallum, Sales Mgr.

**SKYLINE PRODUCTS, INC.,** 819 Grand Blvd., Deer Park, N. Y.

• SPECIALTIES — Precision sheet metal fabrications; Heli-arc, spot and seam welding.

• CONTRACTS—Electronic mobile test bench for F-105.

• LITERATURE—Facilities Brochure (No. **1585** on Card).

• CONTACT — T. G. Perry, V-P, Production, MO 7-8644.

**SOLAR AIRCRAFT CO.,** 2200 Pacific Coast Highway, San Diego 12, Calif.

• SPECIALTIES — Turbine engine driven primary and auxiliary power units; mobile equipment.

• CONTRACTS—Ground power unit for Army missile system; auxiliary power units for helicopters; mobile subsystem study for classified system.

• LITERATURE — Support Equipment (No. **1586** on Card); Turbine Engines (No. **1587** on Card).

• CONTACT—W. C. Benson, Mgr., GSE, BE 3-8241 Ext. 283.

**SOUTHWEST RESEARCH INSTITUTE,** 8500 Culebra Rd., San Antonio 6, Tex.

• SPECIALTIES — Environmental surveys and performance analysis on turbines, engines, and instrumentation which includes field evaluations in the arctic, desert, and tropics; special facilities for fire and safety technology, soil mechanics, mechanical design and development, physical measurements and automation.

• CONTRACTS—Noise abatement in high pressure fuel systems, valves, reducers, and piping for Navy; environmental research for Army for arctic, desert, tropical effects on military equipment; study of applications engineering services and effects of dust ingestion on Pershing missile ground support turbine engine.

• LITERATURE — The Constant Search (No. **1588** on Card).

• CONTACT—S. H. Simpson, Jr., Asst. to Pres., GE 2-5221.

**SPACE CORP.,** Box 5175, Dallas, Texas.

• SPECIALTIES — Jet Engine test cells; altitude and temperature instrument test cabinets; pressurized aircraft cabin leakage testers; gamma ray liquid level detector devices; thrust and weight measuring systems and instrumentation; launching and ground handling equipment.

• CONTRACTS—Jet engine test cells for GAM 77 and GAM 72; bomb positioning equipment for Air Force; altitude and environmental research complex for FAA.

• LITERATURE — Pod handling equipment for B-58 (No. **1589** on Card); Hangers for B-52 and KC-135 (No. **1590** on Card); Missile Erector System for Titan (No. **1591** on Card).

• CONTACT — Ellie Jones, V-P, Contracts.

**SPERRY MICROWAVE ELECTRONICS CO.,** Box 1828, Clearwater, Fla.

• SPECIALTIES—Automatic checkout; readiness and diagnostic testing of electronic equipments; programming, stimuli generators, digital and pulse circuits, with no limitations in capability in the high frequency radar range; semi-automatic evaluation equipment including overall radar performance monitoring of coherent surveillance and air traffic control radars and matched filter search and track systems; advanced spectral measurement instrumentation, frequency coordination monitoring and beacon checkout equipment.

• CONTRACTS—Flight line and automatically programmed field shop; checkout equipment for B-58 Bomb-Nav search, doppler radars and altimeter; beacon test set for measuring Polaris receiver sensitivity, peak power, frequency and beacon reply; radar performance monitor for Talos guidance radar.

• LITERATURE—Radar Performance Analyzers (No. **1592** on Card); Radar Test Equipment and Instrumentation (No. **1593** on Card); Combination Radar Test Sets (No. **1594** on Card).

• CONTACT—J. O. Lalli, Engrg. Plan. Mgr., Tampa, Fla., RE 6-4161.

**STANDARD STEEL CORP.,** 5001 Boyle Ave., Los Angeles 58, Calif.

• SPECIALTIES—Storage, handling, and transport of low temperature liquid fuels; super-insulations for liquid hydrogen.

• CONTRACTS—Portable storage tanks for Thor, rechargers and trailers for Air Force, liquid hydrogen trans-

ports.
• LITERATURE—Cryogenic Capabilities (No. **1595** on Card).
• CONTACT—Thomas Carter, CA 5-4111.

**THE STEARNS-ROGER MANUFACTURING CO.,** Box 5370, Denver 17, Colo.
• SPECIALTIES—Facilities for propellant production, component test, launch, cryogenic and nuclear systems; propellant storage and transfer.
• CONTRACTS—28,000-gal liquid hydrogen Dewar and component test facility for Saturn; 7000-gal. liquid hydrogen pump test Dewar for Air Force.
• LITERATURE — Cryogenic and Missile Facilities Bulletin (No. **1596** on Card).
• CONTACT—W. N. Boyer, Proj. Mgr., AC 2-8484.

**STEWART-WARNER CORP., SOUTH WIND DIV.,** 550 39th Ave., N.E., Minneapolis 21, Minn.
• SPECIALTIES—Advanced compact air compressor designs for field use; filtration components such as mechanical moisture separators, chemical driers, 5-micron filters; automatic condensate dump devices, pre-heaters, thermostatic controlled back pressure valves; manual and automatic controls for missile checkout and operation.
• CONTRACTS — Primary power pack and hydraulic motor-pump for Pershing; low-pressure pressurization package for B-58 ground checkout.
• LITERATURE — Product Data Sheets (No. **1597** on Card).
• CONTACT—J. W. Mahanay, Sales Mgr., SU 8-8611.

**STRATOFLEX, INC., WESTERN DIV.,** 3201 W. El Segundo Blvd., Hawthorne, Calif.
• SPECIALTIES — High-pressure hose assemblies for hydraulic and pneumatic service.
• CONTRACTS—Units for Atlas, Titan, Minuteman.
• LITERATURE—Engineering Data Sheet (No. **1598** on Card).
• CONTACT—J. P. Thomas, Chief Engr., PE 8-6543 Ext. 27.

**STRATOS DIV., FAIRCHILD STRATOS CORP.,** Manor Lane & Orinoco Dr., Bay Shore, N. Y.
• SPECIALTIES — Compact lightweight vapor cycle air conditioners for vans, shelters, trailers and tactical vehicles; air cycle ground air conditioners; high performance heat exchangers; fluid transfer loop electronic system cooling units; long-life air-lubricated fans and blowers; ground air supplies for jet engine starting.
• CONTRACTS — Lightweight air conditioner for equipment cooling in Mauler mobile launch system; lightweight air conditioners for Hawk guidance Heli-Huts; refrigerant compressor for Skybolt ground ready and checkout conditioning system.
• LITERATURE—Ground Support Air Conditioner (No. **1599** on Card).
• CONTACT — R. Borzilleri, Sales Mgr., Def. Prod., MO 5-0100.

**P. A. STURTEVANT CO.,** Addison, Ill.
• SPECIALTIES — Special-purpose torque control tools.
• LITERATURE — Torque Manual (No. **1600** on Card); Fixture Literature (No. **1601** on Card).
• CONTACT—Paul Rathje, Industrial Sales, TE 4-2000.

**SUN ELECTRIC CORP.,** 6323 Avondale Ave., Chicago 31, Ill.
• SPECIALTIES—Hydraulic, pneumatic, electronic, and electrical support equipment for aircraft and missiles; electrical load banks, motor generators and hydraulic test equipment.
• CONTRACTS—Motor generator sets for Atlas; hydraulic components testers for checkout of valves, actuators, pumps, etc., for Air Force; 180 KW electrical load banks for Air Force.
• LITERATURE—Hydraulic Power Carts (No. **1602** on Card); Generator Load Bank (No. **1603** on Card); Motor Generator Set (No. **1604** on Card).
• CONTACT—E. F. Cornwell, Mgr. Sales Admin., NE 1-6000.

**B. K. SWEENEY MANUFACTURING CO.,** 6300 E. 44th Ave., Denver 16, Colo.
• SPECIALTIES—Torque multiplying, measuring and application systems from as low as one inch-ounce up to twenty-thousand foot-pounds; torque wrenches with power ratios of from 3:1 up to 32:1; calibrated atmospheric measuring system with constant gain unaffected by time, temperature, line voltage fluctuations or variations in length of telemetering cable.
• CONTRACTS — High-torque systems for threaded elements in construction and maintenance of Titan missile silos; special torquing system for multi-thousand foot-pounds underwater applications for Knolls Atomic Power Lab nuclear project; proposed multi-channel static alarm system for Sandia.
• LITERATURE—Torque Multipliers (No. **1605** on Card); Torque Testing Instruments (No. **1606** on Card); Description and Specs for Multi-Channel Static Alarm (No. **1607** on Card).

**SYLVANIA ELECTRONIC SYSTEMS DIV., SYLVANIA ELECTRIC PRODUCTS INC.,** 40 Sylvan Rd., Waltham 54, Mass.
• SPECIALTIES—Signal simulation, digital, and go-no go techniques for automatic GSE.
• CONTRACTS—Flight line, base, and depot level GSE for B-58 ECM System; BMEWS radar data take-off monitoring equipment for continuous check of system operation; Army Mobidic mobile computer simulator for training and operational experience.
• CONTACT — Paul Thornberg, Prod. Line Mgr., TW 3-9200.

**THE TALLEY CORPORATION,** 101 Highway & Conejo Rd., Newbury Park, Calif.
• SPECIALTIES — Electromechanical actuators and electric motors for launching and erection platforms; generators and alternators for ground power carts; air valves and regulator valves; umbilical plug valves and missile receptable valves; cryogenic valves.
• CONTRACTS — Linear actuators


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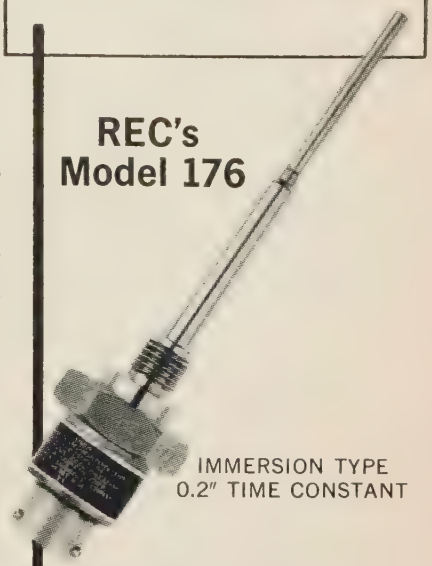

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The Model 176 was designed for storable fuel applications in the missile field. However, it is suitable for use in any part of the −435° to +500° F. temperature range and in any fluid compatible with the stainless steel material of the well. Available in a wide range of lengths, fittings and connectors.

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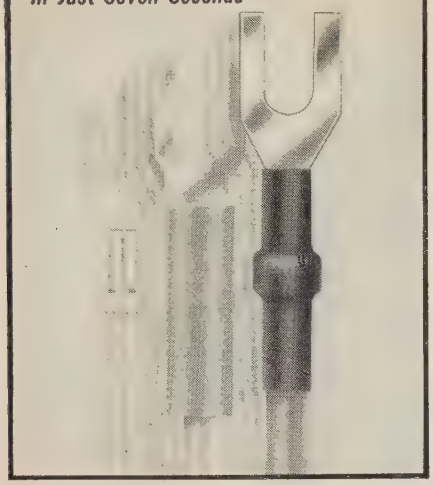

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Shrinkable Tubing is an irradiated Polyolefin insulation that, when heated to 135°C, shrinks within seven seconds to form a permanent, flexible, tight-fitting bond.

Slip it over a group of wires, an exposed connection or component, or even a tool handle needing insulation, apply heat (135°C) for seven seconds — watch it shrink smoothly and firmly to the exact configurations of the object to be covered. Further heating does not affect it.

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for Thor erectors; lightweight high lift electric hoist for Pershing; rotary actuators for Bomarc fuel inlet checkout.

• CONTACT—Norman Nicholson, V-P.

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• SPECIALTIES—Pumping and control of exotic chemical and cryogenic fuels; lightweight, special material transport equipment requiring high degree of technical capability; missile launchers from small tactical to large strategic involving fast response and high mobility; special handling equipment for use in hazardous areas.

• CONTRACTS—Development and tactical prototype production of Pershing transporter-erector-launcher; computer and power drives for Mark 57 and Mark 58 Terrier launcher; control rod drives for Martin.

• LITERATURE—Ground Support Equipment (No. **1608** on Card).

• CONTACT — Stanley Kalikoff, GSE Engr., IV 1-7500.

**TAVCO, INC.,** 612 Colorado Ave., Santa Monica, Calif.

• SPECIALTIES — High pressure pneumatic and hydraulic fluid controls and systems; ground support carts and trailers for servicing and monitoring pneumatic and hydraulic missiles and space vehicle subsystems; low cost pneumatic leak detectors.

• CONTRACTS—10,000 psi oxygen cart and 7,500 psi helium system charging cart for Mercury; high pressure valves for Atlas pneumatic and hydraulic test stands.

• LITERATURE — 6000 psi Pneumatic Shut-Off Valves (No. **1609** on Card); Carts and Test Apparatus Data (No. **1610** on Card).

• CONTACT — C. J. Strid, Sales Engr., EX 4-3781.

**THETA INSTRUMENT CORP.,** 520 Victor St., Saddle Brook, N. J.

• SPECIALTIES — Miniature electronic instruments, dials, and precise position repeaters for GSE; synchro and resolver checkout equipment.

• CONTRACTS—Indicator, synchro, resolver checkout equipment for Gentile AF station; remote indication of inertial system position for Polaris; equipment for F-104 inertial system alignment.

• LITERATURE—Components Catalog (No. **1611** on Card); Servo System Instrumentation Catalog (No. **1612** on Card); Synchro and Resolver Test Equipment Catalog (No. **1613** on Card).

• CONTACT—Stanley Handelman, Sales Mgr., HU 7-3508.

**THIOKOL CHEMICAL CORP., REACTION MOTORS DIV.,** Denville, N.J.

• SPECIALTIES — Equipment for static and environmental testing of rocket propulsion systems; squib check circuitry; automatic checkout for flight and static test use; firing data acquisition and reduction; controls and instrumentation; architectural and engineering services.

• LITERATURE—Capabilities and Qualifications Brochure (No. **1614** on Card).

**THE TORRINGTON MANUFACTURING CO. INC., SPECIALTY BLOWERS,** 100 Franklin Dr., Torrington, Conn.

• SPECIALTIES—Complete air moving or ventilating units for vans, trailers, automatic checkout systems in GSE for missiles and space vehicles.

• CONTRACTS — Titan equipment checkout, Hawk equipment cooling, Mace pressure control checkout.

• LITERATURE—Facilities Brochure #102 (No. **1688** on Card). Specialty Blower Catalog (No. **1689** on Card).

• CONTACT—A. W. Wilczenski, Mgr., Tech. Serv., HU 2-4422.

**THE TRANE CO.,** La Crosse, Wis.

• SPECIALTIES—Air conditioning refrigerant compressors; fin-tube and plate-fin heat exchangers; fans designed for special air conditioning packages.

• CONTRACTS—Compressors and coils for a special Titan I air conditioning package; air conditioning system components for Minuteman railroad trains; refrigerant compressors and air-cooled condensers for Titan II portable refrigeration trailers that cool ethylene glycol.

• LITERATURE—Hermetic Reciprocating Compressors (No. **1615** on Card); Cooling Coils (No. **1616** on Card); Heat Exchangers for Cooling Electronic Equipment (No. **1617** on Card).

• CONTACT—Sales office or Heat Transfer Sales.

**TRANS-SONICS, INC.,** Box 328, Lexington 73, Mass.

• SPECIALTIES—Ground-based and airborne transducers and systems for measurement of level, temperature, pressure, and flow; cryogenics; propellant loading control systems; storage instrumentation and fuel gaging systems.

• LITERATURE—Propellant Loading System (No. **1618** on Card); Liquid Detection Systems (No. **1619** on Card); Cryogenic Temperature Sensors (No. **1620** on Card).

• CONTACT—W. E. Jackson, V-P, Sales, BR 2-1000.

**TRG, INC.,** 2 Aerial Way, Syosset, N.Y.

• CONTRACTS—Stable timing oscillators for Air Force; shielding considerations for handling nuclear powered aircraft and space vehicles; Light Detection and Ranging (Lidar); optical tracking of space vehicles.

• LITERATURE — TRG General Brochure (No. **1621** on Card); LIDAR Brochure (No. **1622** on Card).

• CONTACT—F. N. Mayer, Asst. to Pres., OV 1-6900.

**TRW COMPUTERS CO.,** 8433 Fallbrook Ave., Canoga Park, Calif.

• SPECIALTIES—Automatic checkout and production testing systems; digital control computers, computer input and output equipment, and standard test equipment.

• LITERATURE—RW-300 Digital Control Computer (No. **1623** on Card); TRW-330 Digital Control Computer (No. **1624** on Card); Automatic Control of Production Testing (No. **1625** on Card).

• CONTACT—H. J. Ridinger, Jr., Pub. Rel. Mgr., DI 6-6000 Ext. 2232.

**TURBOCRAFT, INC.,** 1946 S. Myrtle

Ave., Monrovia, Calif.
• SPECIALTIES—Transfer pumps for liquid oxygen, hydrogen, and nitrogen; pumps, valves, and controls for acids and other corrosive fluids and storable fuels; rotary compressors.
• CONTRACTS—Cryogenic pumps for Linde, Rocketdyne, P&W.
• LITERATURE—Product Bulletins (No. **1626** on Card).
• CONTACT—W. P. Harris, Dir. of Engr.

**UNI-FLEX MANUFACTURING & ENGINEERING, INC.,** 5545 E. Slauson Ave., Los Angeles, Calif.
• SPECIALTIES—Liquid gas storage, control, transfer and expansion hardware; vacuum jacketed vessels, pipe and valves; bellows and expansion joints.
• CONTRACTS—Propellant transfer piping incorporating cryogenic bellows for Titan; expansion hardware for Atlas generator exhaust; liquid hydrogen Dewars for Saturn.
• LITERATURE—Vacuum Jacketed Transfer Piping (No. **1627** on Card); Cryogenic Storage, Transfer and Control (No. **1628** on Card).
• CONTACT—John Conley, Sr. V-P.

**UNIT CRANE & SHOVEL CORP.,** 6411 W. Burnham St., Milwaukee 19, Wis.
• SPECIALTIES—Mobile and truck mounted full-revolving power cranes for precise handling of missiles, large missile components, and other GSE at launching sites and point of manufacture; shockless controlled handling of loads with safety and precision.
• CONTRACTS — 30-ton-capacity truck mounted handling cranes for Titan; 30 ton self-propelled rubber-tired wagon crane for in-plant service to handle Polaris and Minuteman rocket engines and fuel containers during production, storage and shipping; 7-ton self-propelled, rubber-tired wagon crane for in-plant service to handle Bomarc.
• LITERATURE—UC Electric Drive Makes the Difference (No. **1629** on Card).
• CONTACT—V. S. Barnes, Sales Mgr., Elec. Cranes, MI 5-8840.

**UNITED CONTROL CORP.,** Box 3104, Seattle 14, Wash.
• SPECIALTIES — Close tolerance, air conditioning and equipment cooling systems; temperature control systems; programming devices and systems; cryogenic liquid level control and monitoring systems; remote positioning systems; changeover switches; radio frequency interference testing and filtering.
• CONTRACTS—Minuteman guidance and control compartment temperature control; Titan low-level sensors for liquid oxygen; programmer for Polaris.
• LITERATURE — Controls for Flight Catalog (No. **1630** on Card); Radio Frequency Interference Filtering Booklet (No. **1631** on Card); Research and Development Capability (No. **1632** on Card).
• CONTACT—T. A. Weiss, Jr., V-P, Sales & Mktg., TU 5-3711.

**UNITED MANUFACTURING CO.,** 41 Haig St., Hamden 14, Conn.
• SPECIALTIES—Aircraft, missile, rocket test equipment; special vans,


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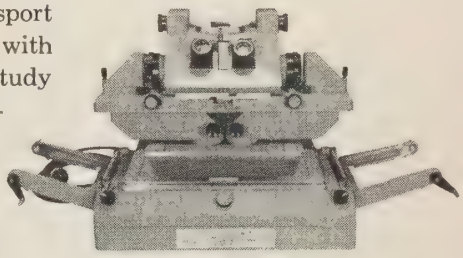

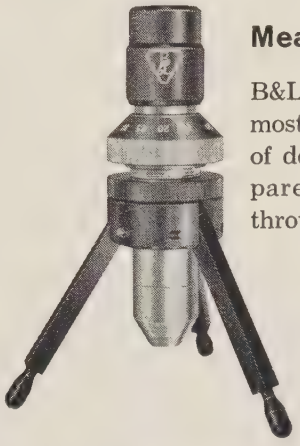

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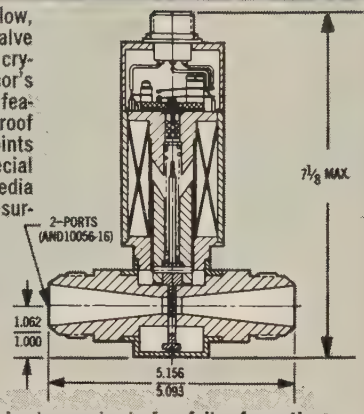


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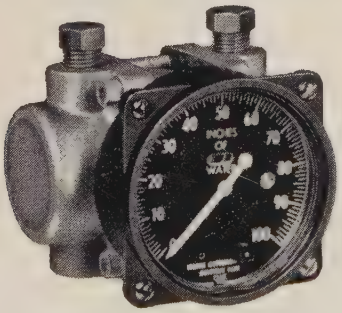

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trailers, and vehicles for aircraft sevicing and maintenance; special power supplies; laboratory facilities.

• CONTRACTS—Constant-speed drive test stand for F-101, B-58, B-52, F-106, B-47, KC135, etc.; electronic coolant supply stands for supplying controlling and monitoring cooling fluids for electronic devices on Hawk program; portable hydraulic carts for testing Titan launcher cylinders and portable DC load banks for missile checkout.

• LITERATURE—Electronic Coolant Units (No. **1633** on Card); Constant Speed Drive Test Stand (No. **1634** on Card); Portable Hydraulic Cart (No. **1635** on Card).

• CONTACT—V. A. Stancliff V-P & Genl. Mgr., CH 8-4491.

**THE UNITED MANUFACTURING CO.,** 5250 Dobeckmun Ave., Cleveland 2, Ohio.

• SPECIALTIES—Trailers, dollies, skids and mobile stands for the handling, transport and storage of bombs, munition, missiles and jet engines; fabrication experience in both steel and aluminum.

• CONTRACTS—Aluminum munitions handling trailers for Air Force; four wheel weapons and missiles skids; handling stands for transport and position jet engines during removal and installation on aircraft.

• LITERATURE—Technical Catalog (No. **1636** on Card).

• CONTACT—W. R. Albrecht, Sales Mgr., OL 1-6310.

**UNITED NUCLEAR CORP., DEVELOPMENT DIV.,** 5 New St. White Plains, N.Y.

• SPECIALTIES—Handling radioactive and non-radioactive nuclear parts and equipment; design of devices for handling "hot" items.

• LITERATURE—Hot Laboratory Facilities (No. **1637** on Card).

• CONTACT—W. S. Mott, Mgr., Development, WH 8-5800.

**VACCO VALVE CO.,** 1445 Lidcombe Ave., El Monte, Calif.

• SPECIALTIES—0-3600 psi manual valves, air operated valves, check valves, relief valves, regulators, back pressure regulators, ball valves, etc., for propellant handling and transfer systems; valves for cryogenics handling, bellows stem seals, air actuated and manual or electric motor operated valves with temperature range to 1600°F. for nuclear handling.

• CONTRACTS—All high pressure helium control valves for Atlas sites; R&D components for Titan II (storable) sites; high pressure gas components for Titan I.

• LITERATURE—Facilities Brochure (No. **1638** on Card); Condensed Catalog (No. **1639** on Card); General Catalog (No. **1640** on Card).

• CONTACT—George Kay, V-P & Sales Mgr., CU 3-8337.

**VAP-AIR DIV., VAPOR CORP.,** 80 E. Jackson Blvd., Chicago 4, Ill.

• SPECIALTIES—Temperature control systems, temperature monitor systems, battery charges, power supplies, pneumatic pressure regulators.

• CONTRACTS—Guidance and control compartment temperature control system, transport temperature monitor system, and missile container temperature control system for Minuteman.

• LITERATURE—Battery Chargers (No. **1641** on Card); Merc Thermostats (No. **1642** on Card); Power Supplies (No. **1643** on Card).

• CONTACT—K. E. Toreson, Mgr., Sales Liaison Dept., NE 1-9200.

**VARO INC.,** 2201 Walnut St., Garland, Texas.

• SPECIALTIES—Static power conversion equipment (inverters, converters, etc.). Frequency changers and control. Frequency standards for use in automatic checkout.

• CONTRACTS—Multiple output precision power for Minuteman. Speed control for F-106. Precision static inverter for SINS.

• LITERATURE—Model 4342 (No. **1690** on Card); Model 4678 (No. **1691** on Card); Model 4338 (No. **1692** on Card); Model 4345 (No. **1693** on Card).

• CONTACT—Ray Gilmer, V-P, Mkt., BR 6-6141.

**VIDEO INSTRUMENTS CO., INC.,** 3002 Pennsylvania Ave., Santa Monica, Calif.

• SPECIALTIES—Electronic equipment for data acquisition; strain gages, thermocouples, resistive thermeters transducers, etc.; signal conditioning equipment.

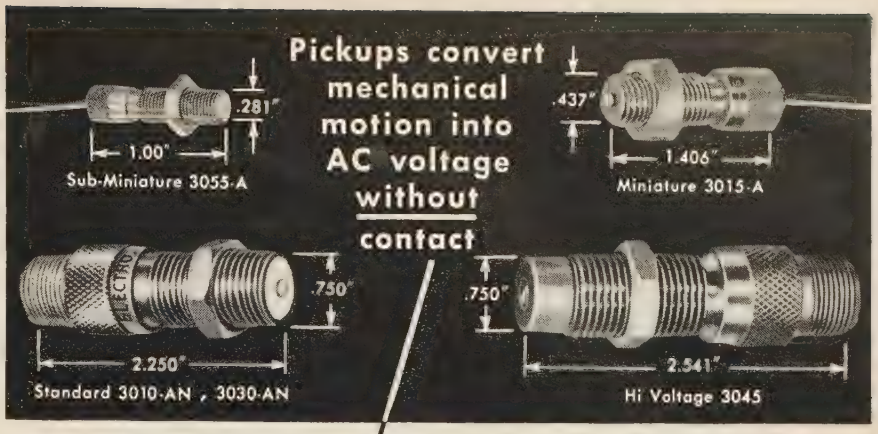
• CONTRACTS—Units for Polaris, Titan 1 and 2, Rover.
• LITERATURE — DC Amplifiers Catalog (No. **1644** on Card); Signal Conditioning Equipment (No. **1645** on Card); Common Mode Problems (No. **1646** on Card).

**VINSON MANUFACTURING CO., INC.,** 8044 Woodley Ave., Van Nuys, Calif.
• SPECIALTIES — Hydraulic and pneumatic valves and regulators for checkout systems and launcher-loader operations.
• CONTRACTS—Pneumatic valves and regulators for Atlas ground checkout system; valves and regulators for Titan launcher-loader and checkout; relief valves for Hawk loader and launcher.
• LITERATURE—Will It Work up Here? (No. **1647** on Card); This Valve Solves Six Control Problems (No. **1648** on Card); Will This Valve Solve Your Problem? (No. **1649** on Card).
• CONTACT — W. A. Goodman, Sales Mgr., TR 3-3510.

**WANG LABORATORIES INC.,** 12 Huron Dr., Natick, Mass.
• SPECIALTIES—Block tape reader for programming automatic checkout equipment; encoders and systems for antenna azimuth and elevation readout; high speed data transmission equipment.
• CONTRACTS—Nike radar antenna readout; semiautomatic telecode transmitter for Air Force; programming Boeing missile checkout equipment with block tape reader.
• LITERATURE — Semiautomatic Telecode Transmitter (No. **1650** on Card); Angular Position Encoding Systems (No. **1651** on Card); Block Tape Reader (No. **1652** on Card).
• CONTACT—F. L. Gosnell, Sales Mgr.

**WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.,** 979 Rollins Ave., Rockville, Md.
• SPECIALTIES — Fabrication of blockhouse instrumentation; satellite payload preflight checkout; mobile trailer instrumentation and operation; test and field evaluation; flight data reduction.
• CONTRACTS — Talos training weapon for Navy; Arctic meteorological photo probe for NASA; electronic and mechanical fabrication services for NASA.
• LITERATURE—WTA Capabilities (No. **1653** on Card); WTA Organization for Manufacturing (No. **1654** on Card); The WTA Brochure (No. **1655** on Card).
• CONTACT—Larry Hastings, PR Dir., HA 7-7550.

**WATERTOWN DIV., NEW YORK AIR BRAKE CO.,** Starbuck Ave., Watertown, N.Y.
• CONTRACTS—Equipment for Hawk loader and launcher; Hawk maintenance van, and Sergeant missile.
• LITERATURE—Hydraulic Pumps (No. **1656** on Card); Hydraulic Motors (No. **1657** on Card).
• CONTACT—J. M. Coughlin, Supv., SU 2-7000.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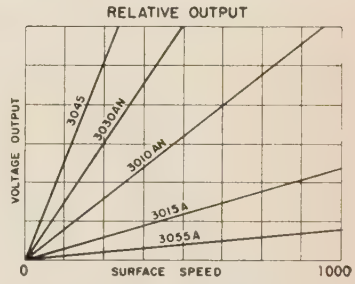


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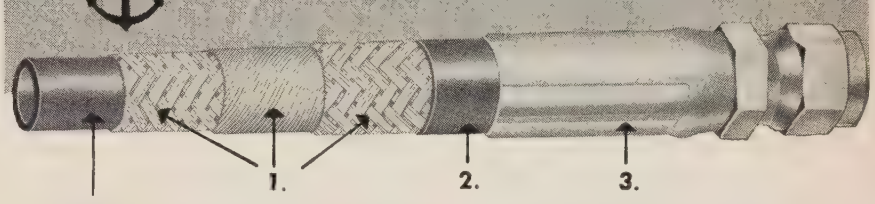


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• SPECIALTIES—Turbine flow sensors and associated electronics for peripheral instrumentation; flowmeters; miniature solid state electonic packages for timing and programming using magnetic elements for counting; frequency to DC converters; preset counters; add-subtract counters and scalers.

• CONTRACTS—Flow metering indication of liquids and gases for Titan II; gas flow metering for Atlas; flow metering for GAM-72.

• LITERATURE — Turbine Flow Sensors (No. **1658** on Card); Frequency to DC Converters (No. **1659** on Card); Subminiature Digital Frequency Divider Modules (No. **1660** on Card).

• CONTACT—R. E. Day, Mktg., TR 3-1055.

**THE WEATHERHEAD CO.,** 300 E. 131st St., Cleveland 8, Ohio.

• SPECIALTIES—Quick disconnect and self-sealing breakaway couplings; pneumatic regulators for —65 to 400 deg F; pump and directional controls; hydraulic drives; high pressure hose and fittings.

• CONTRACTS — Rail Minuteman (AMF); Titan silos (AMF).

• LITERATURE — 207 Hydraulic Pump Brochure (No. **1661** on Card). Selector Control Valves W-1234 (No. **1662** on Card). Teflon & Fitting Aviation Catalog—AC302T & F (No. **1663** on Card).

• CONTACT—W. W. Bortner, Sales Mgr., Aviation & Missile Prod., GL 1-5200.

**WEBER AIRCRAFT CORP.,** 2820 Ontario St., Burbank, Calif.

• SPECIALTIES—Aircraft boarding ramps, maintenance stands, metal shipping containers, mobile lighting systems, trailer vans, transport trailers, mobile ground power units.

• CONTRACTS—Equipment for Air Force, Douglas, Standard Oil.

• LITERATURE — Spacecraft-Aircraft Test Facilities (No. **1664** on Card); Weber's Mobilite (No. **1665** on Card); Ground Air Support Equipment (No. **1666** on Card).

• CONTACT — Don Adams, Sales Engr., VI 9-1181.

**WESTINGHOUSE ELECTRIC CORP.,** Box 2278, Pittsburgh 30, Pa.

• SPECIALTIES — Nuclear, steam and gas turbine ground power supplies; launchers; elevators; air conditioning; electronic checkout; lighting; meters and instruments; air handling systems; electrical drive systems, missile handling equipment; traveling gantries; high-shock electric and mechanical apparatus for hardened installations; ultra lightweight generation equipment; large precision machined parts; arc air heater facilities; rotating and static converters and inverters; large radar and radio antennas.

• CONTRACTS—Launcher for Polaris; radar and direction for Typhon Project; missile bases distribution equipment for Titan.

**WESTINGHOUSE ELECTRIC CORP., AEROSPACE ELECTRICAL DEPT.,** Box 989, Lima, Ohio

• SPECIALTIES—Synthetic analog and digital inputs for automatic checkout and bench test equipment; automatic analog and digital output measurements; magnetic tape, punched paper and selector switch programming; reliability test equipment; quantative and go-no go readout; power semiconductor, relays, transformer testers.

• CONTRACTS—Automatic analog and digital tests of electrical system controls for B-52H and Boeing.

• CONTACT—A. C. Chiazza, Sales Mgr., CA 4-0121.

**WHITTAKER CONTROLS DIV., TELECOMPUTING CORP.,** 915 N. Citrus Ave., Hollywood 38, Calif.

• SPECIALTIES—Regulators, cryogenic valves in all sizes, high pressure control valves.

• CONTRACTS—High pressure cryogenic shut-off valves for Titan.

• LITERATURE—Gate Valve Brochure (No. **1667** on Card); Underwater


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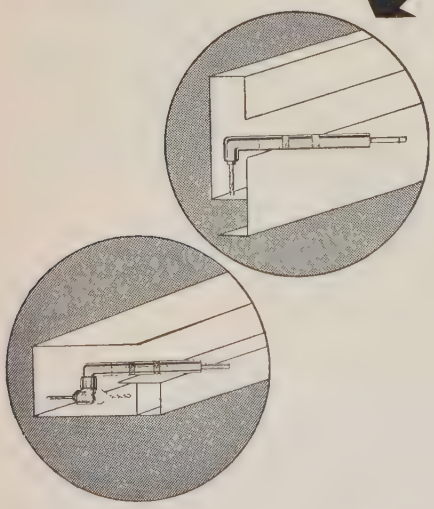

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## Another Extra in December

Next month, SPACE/AERONAUTICS will do for the electronic designer what we hope this month's second part does for the support specialist.

In addition to our regular issue, we will offer a completely self-contained package of "Design Guidelines for Space and Airborne Electronics," including two staff-written surveys of general design practices and environmental factors and a series of articles by electronic experts.

If you're working on aircraft, missile, or spacecraft electronics, we think you'll keep Part 2 of the December 1961 SPACE/AERONAUTICS on your desk for many months to come.

Launch Brochure (No. **1668** on Card); Pneumatic Controls and Components Brochure (No. **1669** on Card).

• CONTACT—G. F. Anisman, Dir. of Field Engrn., HO 4-0181.

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• SPECIALTIES—Accelerometers

• LITERATURE — Linear Accelerometers (No. **1670** on Card).

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• LITERATURE—Condensed Catalog (No. **1671** on Card); Inst-O-Matic Couplings (No. **1672** on Card); Wig-O-Flex (No. **1673** on Card).

• CONTACT—Gordon Schoenmann, Admin. Asst., AN 9-0181 Ext. 283.

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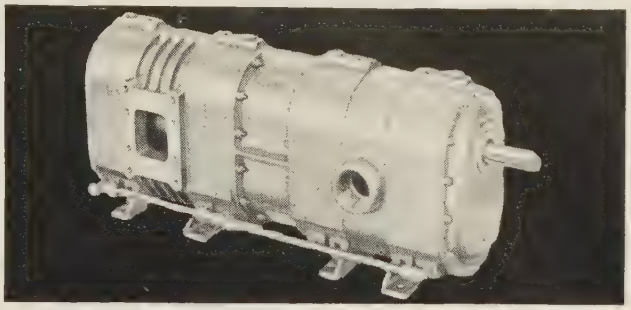

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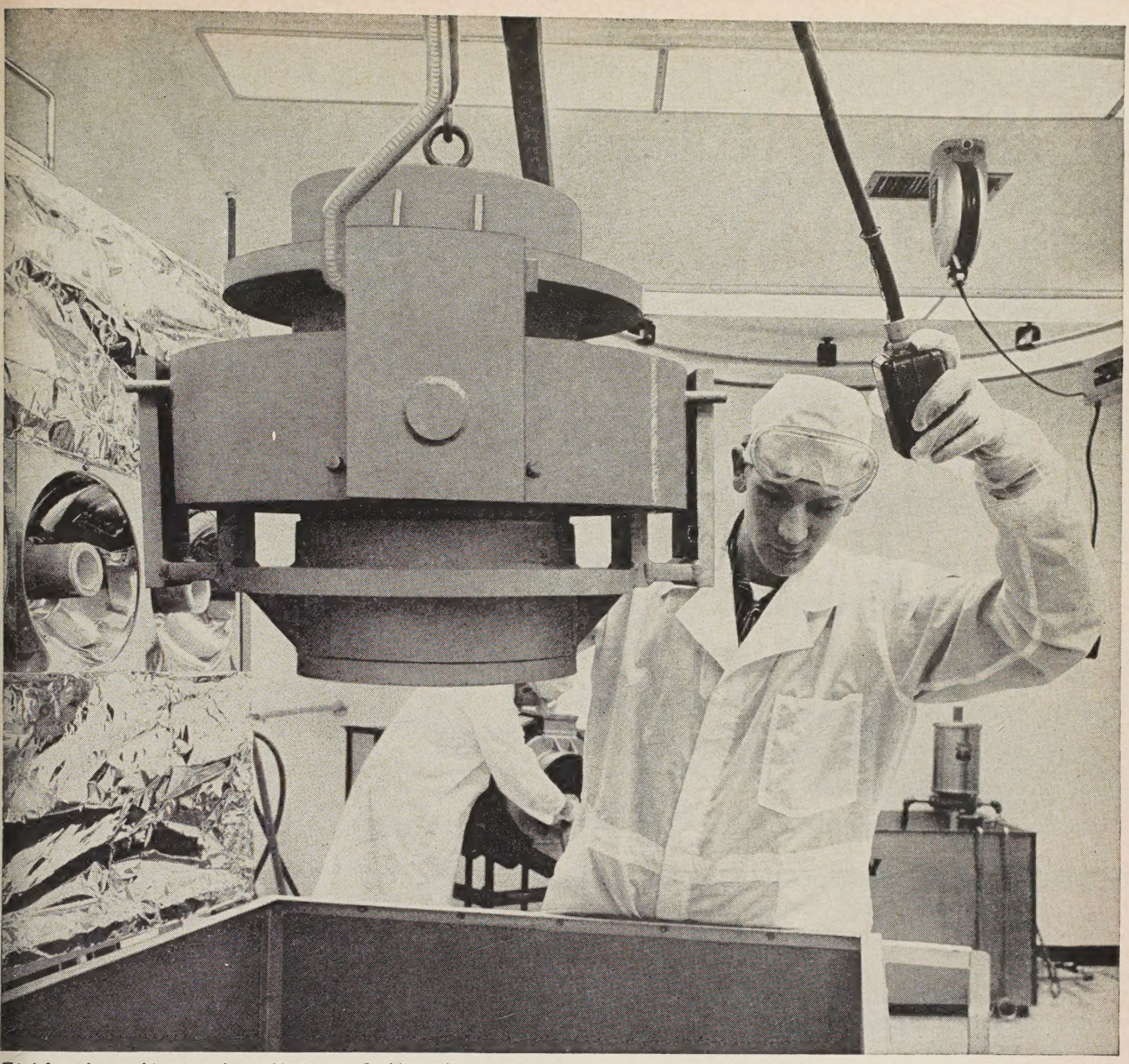

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# MOUNTING SYSTEMS FOR GROUND SUPPORT EQUIPMENT

- computers
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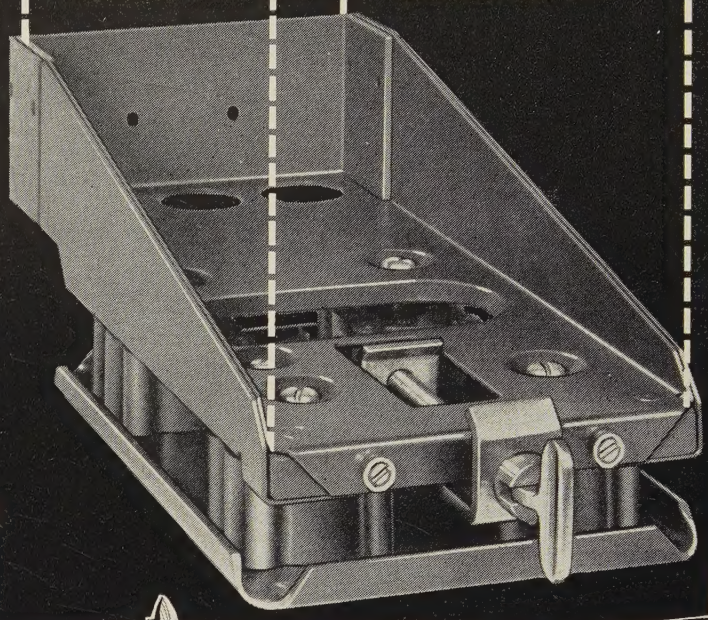
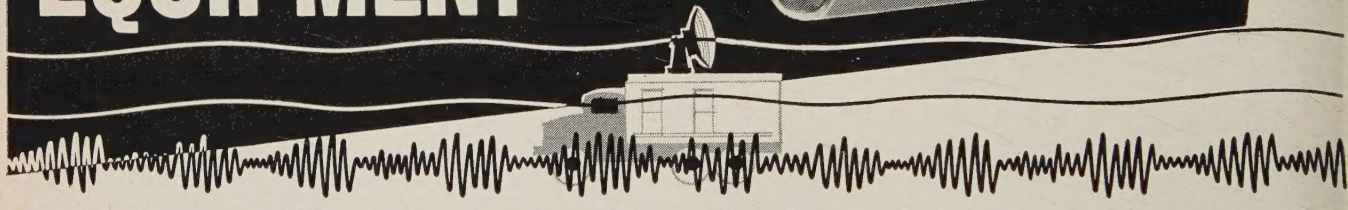
- instrumentation
- recorders

- communications equipment
- check-out and test gear
- control and guidance units
- data processing units





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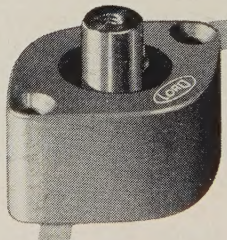

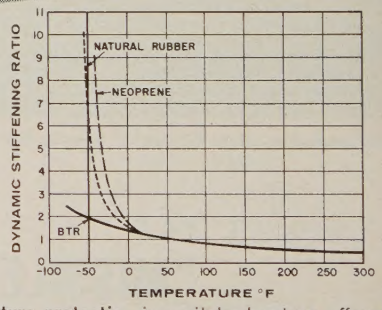


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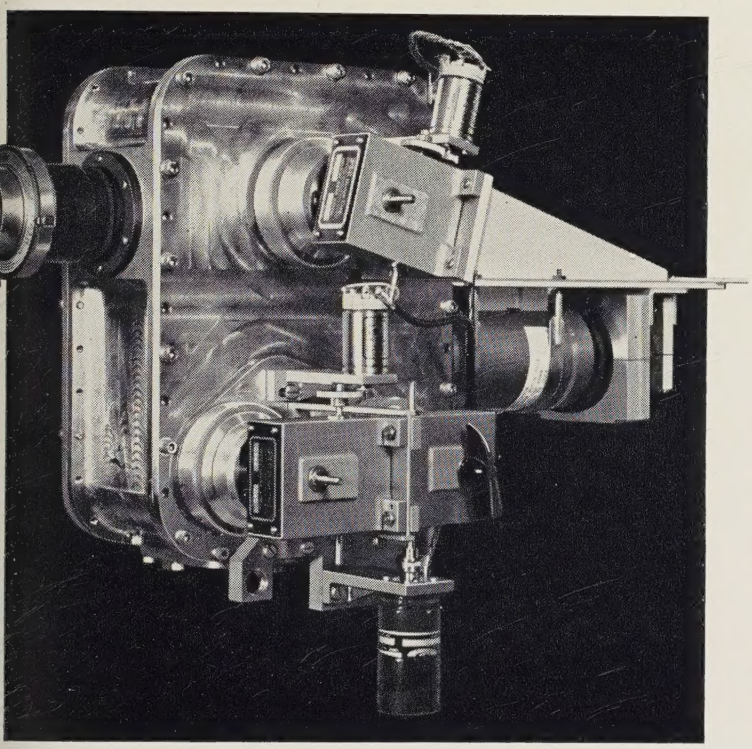
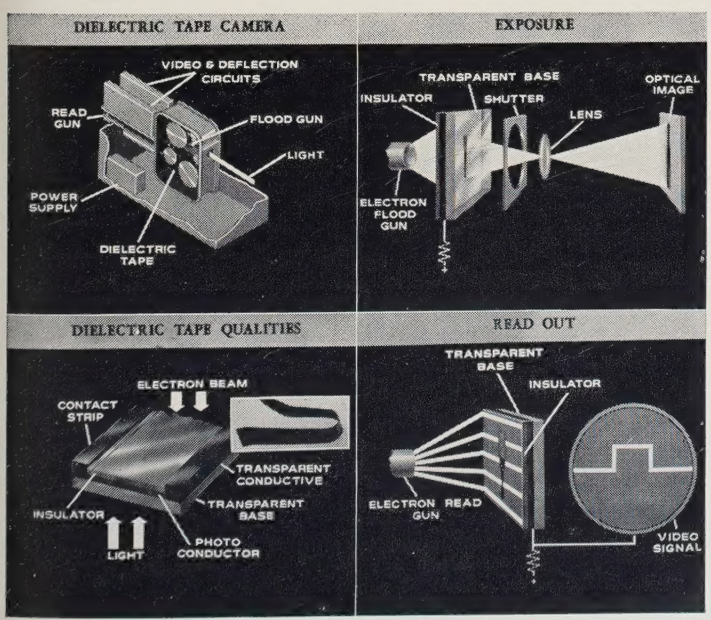
# PHOTO-DIELECTRIC TAPE CAMERA SYSTEM

## . . . a major advance in space image-sensing






The development of photo-dielectric tape permits the design of a totally new image-sensing system for utilization in satellites and space vehicles. A prototype camera for use with this tape has already been operated and tested. This system, one of the first developed primarily for use in space, offers a number of advantages over existing photographic and television techniques.

Operating on the principle of storing an optical image by converting it to an electronic charge pattern, the photo-dielectric system has inherently high resolution since the picture charge pattern is read out directly as a video signal by an electron beam Moreover, it offers real promise of providing response in various parts of the radiation spectrum in addition to the visible including infrared and ultraviolet with sensitivity better than standard photographic techniques.

Readout is accomplished by use of a finely focused electron beam which scans the charge pattern. It is then converted directly to a video signal for transmission to the ground. Readout can be accomplished at different speeds to compensate for various power and band-width requirements dictated by the nature of the space mission.

The flexibility of the system permits readout of the same image numerous times, if desired, by ground control. In the laboratory, the same image has been read out up to 100 times without serious degradation of quality. Yet, the image is erased completely, with no trace of "sticking," as the tape is flooded with electrons prior to exposure. Transistorization of the package results in minimum weight and low power requirements.

Since a high vacuum is essential to the operation of a photo-dielectric tape camera system, it is "at home" in the harsh environment of space. Also, dielectric tape is virtually unaffected by radiation thereby eliminating this hazard to ordinary photographic film. It is also reusable and serves as its own storage medium for remote picture-taking sequences.

To find out how RCA's new photo-dielectric tape camera developments can fill your requirements for space image-sensing systems, write to the Manager, Marketing, Astro-Electronics Division, Defense Electronic Products, Radio Corporation of America, Princeton, New Jersey.

And for a challenging, rewarding career in electro-optical systems development, apply to the Employment Manager, RCA Space Center, Princeton, New Jersey. All qualified candidates are considered regardless of race, creed, color or national origin.

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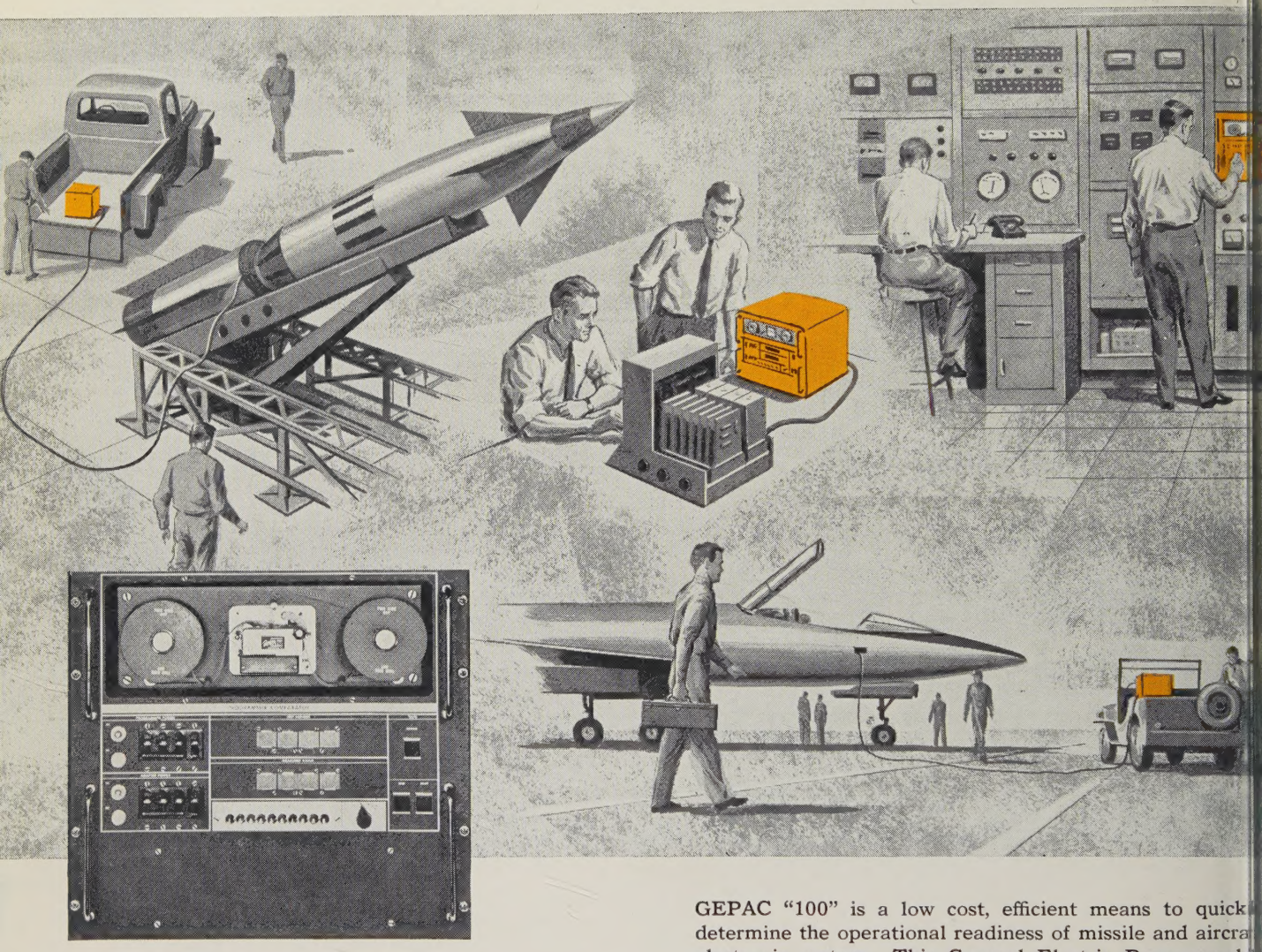



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